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METALS & ALLOYS

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Devoted to the Advancement of Scientific Metallurgy

Metals Used in Aircraft Construction

BRADLEY STOUGHTON

Aluminum and Its Alloys in Aircraft

T. W. BOSSERT

A Study of Barium-Tin Alloys

K. W. RAY and RALPH G. THOMPSON

Recent Developments in Metallurgy of Cast Iron

RICHARD MOLDENKE

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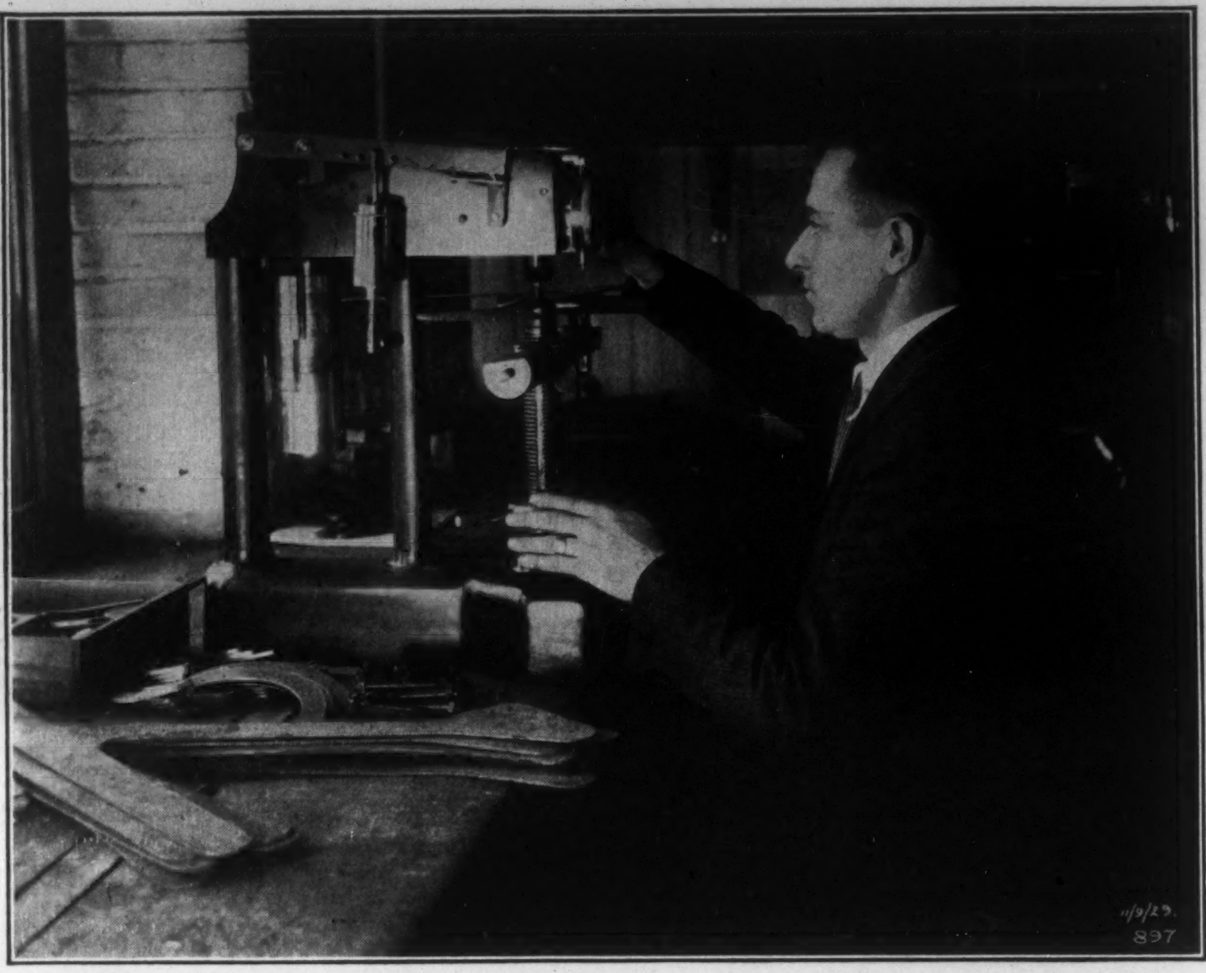

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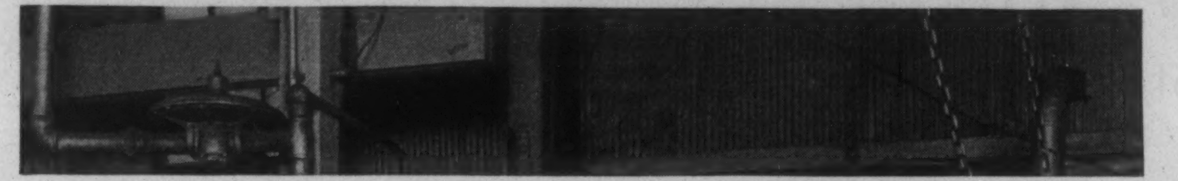

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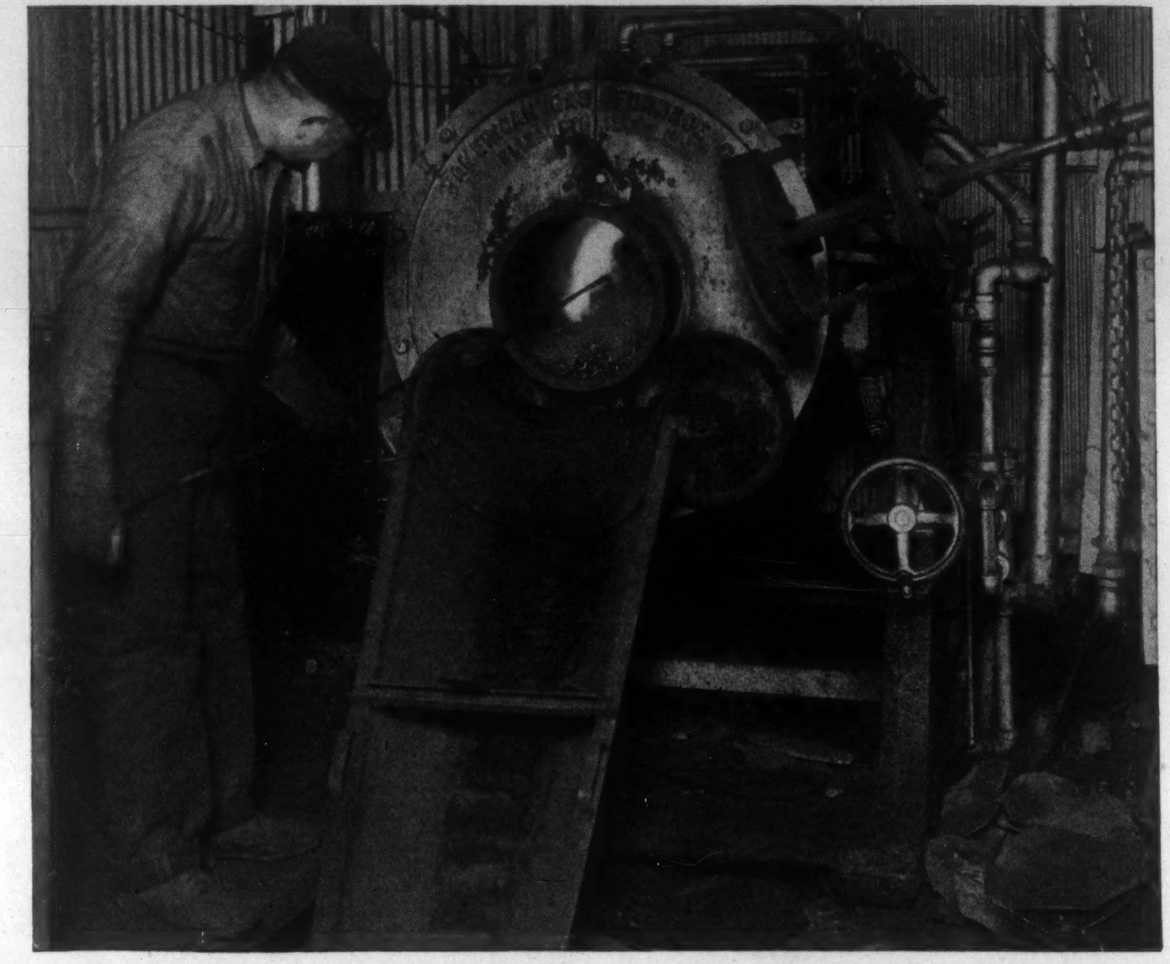

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PUBLISHER'S PAGE

Note— On this page the publishers will talk right straight to you each month. We will tell you how things are progressing with METALS & ALLOYS. *We will undoubtedly ask your advice on many points. We are publishing this paper not primarily to please ourselves but rather to serve you. And our office door is always open. You are invited to call.*

We Want to Hear Both Sides

Ever since we brought out the first issue of METALS & ALLOYS in July 1929 we have been receiving letters congratulating us on the general character of the publication and expressing approval of the material we have been furnishing. Naturally we are pleased that this is the case but we have a suspicion that possibly we are only hearing one side of the story, and that there may be a considerable group of our readers who are not so completely pleased with the publication, but who have refrained from expressing their opinion either out of consideration for our feelings or simply from inertia.

If so, we earnestly hope that these readers will take the trouble to write to us and give us an idea of how, in their opinion, METALS & ALLOYS could be made to serve their interests more completely. The present season brings with it the necessity of mapping out our editorial plans and policies for the new year and we are anxious that our program should represent not merely the ideas of ourselves and our editorial staff as to how the paper should be conducted, but also the ideas of our readers.

Our own theory as to the maximum usefulness of METALS & ALLOYS is that it should, while being a strictly scientific paper providing a medium for the publication of the most advanced developments of metallurgical technology, nevertheless be at the same time eminently practical in the sense that it would help men actually in charge of metallurgical manufacturing operations to develop their processes and products to the highest degree of efficiency in the light of the latest advances in the science of metals.

Furthermore, it is our idea that it should serve the metallurgical public generally, making no distinction between so-called "scientific" and so-called "practical" men; no distinction between ferrous and non-ferrous metallurgists; and that it should help to acquaint those metallurgists who are working in universities, government departments and research institutions with the problems confronting their colleagues who are working in industrial plants; and, at the same time, let the industrial men know what is being done by the research men so that as quickly as possible it may be translated into plant practice, to the benefit of the industry as a whole.

If, in your opinion, the above is an impossible ideal please let us know. If you feel that we are erring on the side of publishing too much theoretical metallurgical science we want to know that. We might mention in passing that such a series of articles as that by Dr. George L. Clark on "X-Ray Metallography" in our first five issues, although essentially advanced and scientific, has evoked letters of approval from a large number of practical men connected with railroads, foundries, steel mills and other industrial metallurgical establishments.

We have planned for the coming year a series of thoroughly scientific but at the same time entirely practical articles on foundry practice by Dr. Enos of Cincinnati who for the past few years has been conducting a most successful evening school for foundrymen. We expect to publish similar material on heat treating, furnace design and operation, electroplating, and many other subjects of industrial importance. Suggestions for further developments along these lines from any of our readers will be given the most careful consideration and we hope that you will take time to favor us with them.

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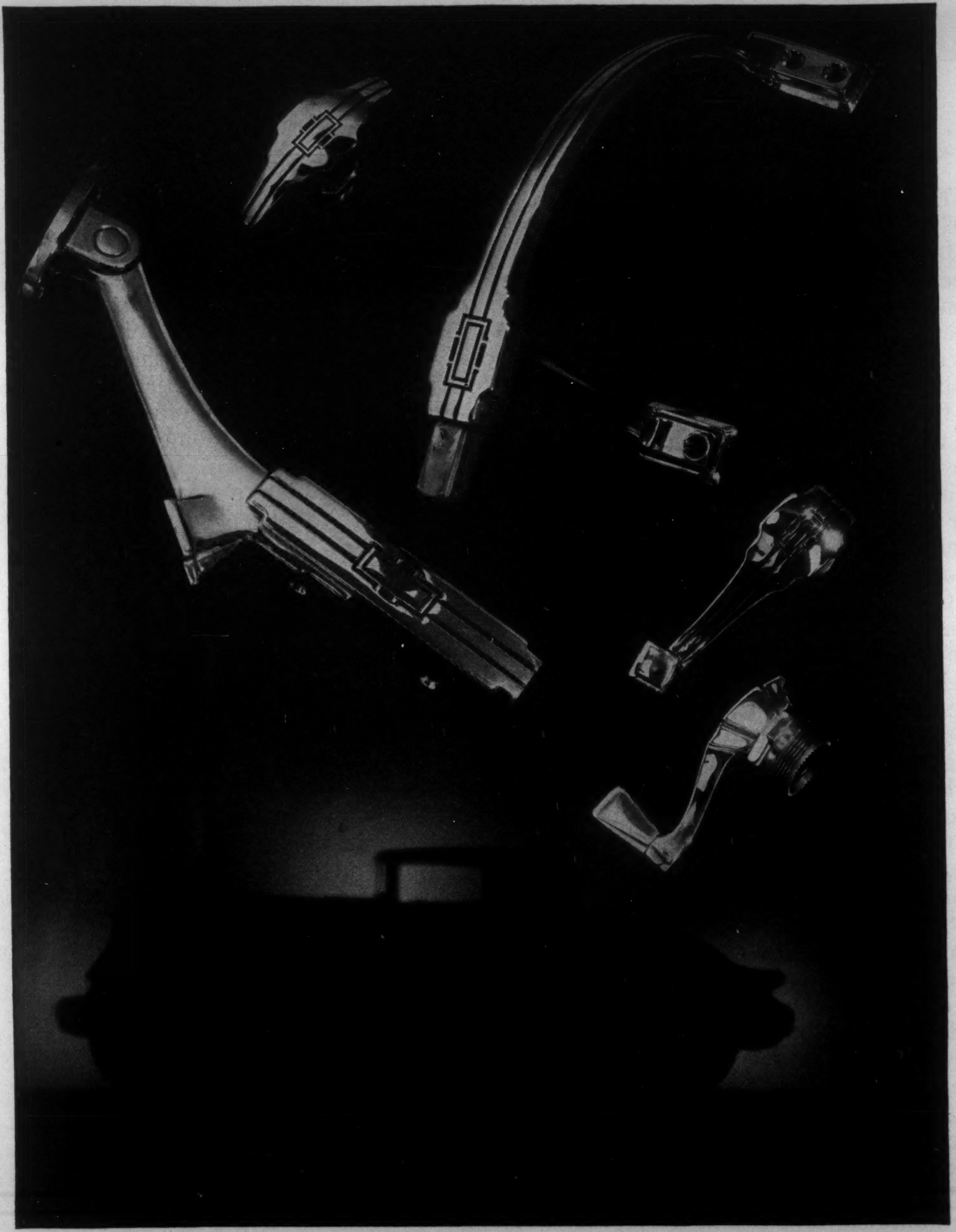

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Editorial Comment

In this department I try to comment on metallurgical and allied matters that seem to me interesting and significant. The views expressed reflect my own personal attitude. Many of our readers will have ideas of their own on these subjects and are urged to contribute them in the form of letters which will gladly be published in succeeding issues.—H. W. GILLETT, *Editorial Director.*

Technical Censorship of Advertising

The persistence of erroneous phraseology is appalling. H. F. Moore pointed out ten years ago, and it has been reiterated by all workers in fatigue of metals ever since, that metals do not "crystallize" under repeated stress. Metallurgists certainly know better, engineers ought to and the mechanic should begin to by this time.

The misconception has been widespread in spite of the efforts to correct it, and to substitute accurate terminology. The Bureau of Standards issued a letter circular (No. 204) on the subject, which can be had on application.

No one would be surprised if a small town blacksmith still used the wrong term, but it is surprising to find on page 570 of the October 1929 issue of the *General Electric Review*, in what is practically an advertising note on a new product, the following: "A common cause of trouble in outdoor station installations is the fact that the conductors break as a result of crystallization close to the point where they are rigidly held to the connection members of oil circuit breakers, transformers and disconnecting switches. This danger has been eliminated by a guide clamp. Its function is to distribute the occurrence of the point of flexure over an appreciable length of conductor, and thus to relieve the metal adjacent to the connecting studs of the full effect of vibration and swinging."

The General Electric Company has not only contributed toward the fatigue investigation at the University of Illinois, but its Research Laboratories engage in endurance testing. On page 535 of the same issue is a photograph of a fatigue test bar built up by atomic-hydrogen welding for test. A good many people in the General Electric organization know better than to call a fatigue failure "crystallization." But since this knowledge is so little disseminated within the organization as to make it possible for such a statement to occur in the company's own technical journal, when may we expect the average garage mechanic to acquire the knowledge and use the proper terms? We'd say about 100 years from now, unless the laboratory man takes the advertising man by the ear, and insists on censoring his output.

We recall an advertisement put out a couple of years ago by one of our most progressive steel companies, which has a large and capable metallurgical staff. The advertisement recited, in detail, tests showing that a certain product was less attacked by aqueous hydrochloric acid than competing products, and allowed the reader to draw the conclusion that the product was thereby proven to be fitted for its purpose, which was to withstand atmospheric exposure.

Now, the American Society for Testing Materials found it necessary, in 1928, in the hope of curbing misleading propaganda, to restate the obvious fact that acid corrosion tests and natural corrosion have no necessary relationship.

We were interested enough in the matter to write the editor of one of the most widely distributed metallurgical trade journals in which the advertisement in question had appeared in a prominent position, and to ask "how come?" He replied that they relied on the technical staff of the advertiser to make the advertisements technically truthful. That is probably all any journal can do, especially since copy may not come in until the last moment.

But in this case we were assured by the firm's metallurgical staff that they knew the advertisement made the firm ridiculous in the eyes of any metallurgist, but their statements to that effect had no effect whatever on the advertising staff, which frankly didn't give a hoot about the technical facts as long as the advertisement read well to them.

We don't believe it pays to make one's firm ridiculous in anyone's eyes. No advertisement purporting to deal with technical matters ought to go out without the O.K. of the technical staff. If such O.K.'S were obtained before publication, fewer misapprehensions would be perpetuated.

Clippings

Information is of no use if you can't find it. Its value increases as its accessibility increases.

There are two ways of filing current information, both of which have advantages. In one, the journal in which the information appears is bound, unmutilated, and goes into the library. In this case, to save running through the annual index after one has forgotten the year of publication, it is wise to keep a card index of the titles and authors of the articles of interest. In the other, the article is clipped and filed under some pertinent general subject heading. This makes one article available, but spoils the next article, part of which may be on the back of the clipped pages, and much is thrown away that, at the moment, one is not sufficiently interested in to file, but which next month one may want desperately to lay his hands on.

The clipping and filing of abstracts is especially useful because it keeps up a perpetual inventory of available knowledge, filed under the headings which the individual or group using that file will look for them under, and these headings will vary with every business and every firm.

Many plant librarians, laboratories and individuals are making card indices by subjects only, which are far less valuable than they would be were the abstract also on the card.

Paper and print are cheaper than time, hence it is a real saving to have several copies of technical journals, especially those carrying abstracts. One of these can be kept intact for binding and library use. The others can be circulated to the various individuals interested, who can check off the articles and abstracts that should be clipped and filed.

In common with most other technical journals, METALS & ALLOYS makes a special rate for extra copies to be thus used, in order to facilitate this. Anyone who has available such a clipped and pasted card index of abstracts will find the file far more convenient than trying to use the yearly indices. Making one's own selection of the subjects to be covered, and of the articles and abstracts to filed, keeps the file down to just the material that is of use.

Printed information is to-day the technical man's most important tool, the one he needs first in the study of any problem. This tool should be kept in as usable shape, and as readily available as any other.

Readers' Views and Comments

To the Editor of Metals & Alloys:

Dear Sir: In the November number of Metals & Alloys, page 241, the writer noted an abstract of the article by J. Galibourg from *Revue de Metallurgie* for June. This deals with the effect of aging on over-strained steels. Since this is in line with certain research being conducted by the writer at the present time, the original article was consulted. As a result of this study, it would seem that the abstract which was printed in Metals & Alloys is a little misleading.

This abstract speaks of raising the elastic limit (or apparent elastic limit) by aging after over-strain. It seems that the original article makes use of two words or expressions, namely, "limite elastique apparente" and "palier," using them more or less interchangeably. Now, the first may well be translated "apparent elastic limit." However, this term has a very special meaning in the literature devoted to testing materials in this country.

The term was first proposed by J. B. Johnson, Dean of the College of Engineering, University of Wisconsin, about 30 years ago. It was an arbitrarily defined stress intended to serve in place of a true elastic limit for materials such as the copper alloys in which a true elastic limit is commonly lacking. The term was adopted by the A. S. T. M. in their tentative specifications of 1924, and now is described in the 1929 tentative standards E6–25T.

A study of the original article whose abstract is being discussed, makes it obvious that the writer of that article does not mean what this term (apparent elastic limit) means to the American engineer.

The second term used, namely "palier," means a "level spot" or a "landing place" and by comparing the text with the figures, it is quite evident that M. Galibourg means by this term exactly what the American engineer understands by the term, "yield point." There can be no doubt in this case because of his detailed discussion of the phenomenon in certain parts of his descriptive matter.

Obviously, from the above, the term "yield point" which appears in a few places in the abstract should have been used in every instance where "elastic limit" or "apparent elastic limit" appears.

The original writer, M. Galibourg, made no attempt to determine "true elastic limit" nor did he even attempt to locate the end of the straight line in the load-elongation graph since this requires measurements to within 0.0001″ and his elongations were plotted autographically with a magnification of only two times.

Respectfully yours,
Irving H. Cowdrey

Assoc. Prof. of Test. Mat.,
Mass. Inst. of Technology

Editor's Note: This is a good example of the confusion in terminology in respect to yield point and the various "elastic limits." It is to be hoped that the A. S. T. M. committee dealing with these matters will clarify the situation.

It appears to us that the practice followed by some German testing engineers who use a subscript showing the percentage extension under load taken as the criterion of "yield," is a praiseworthy one. The engineer may then use his judgment as to how much permanent deformation, beyond the elastic deformation, is a proper criterion for the service he has in mind when making the tests, but the reader will not be in doubt. That is, when 0.2% is the criterion, that sort of a "yield point" will not be confused with one determined on the basis of 0.01%. In some alloys, and for some uses, either criterion may be proper.

If testing engineers were clear and precise in reporting their tests, it would make less difference whether or not there was uniformity in testing methods.

To the Editor of Metals & Alloys:

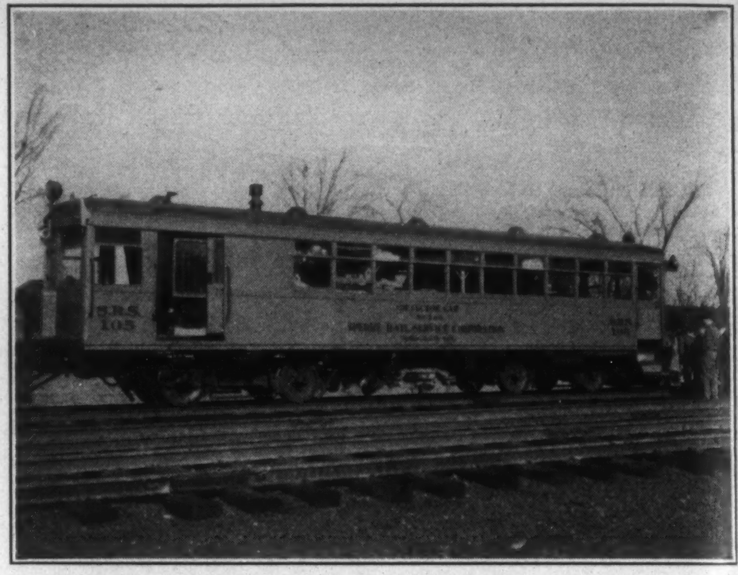
Dear Sir: The very interesting paper by Dr. M. E. McDonnell in the September issue of Metals & Alloys covered the shrinkage crack angle of the fissure problem rather completely. However, his statements and observations on the Sperry detector car were based on a test run made the week of December 2, 1928, just five weeks after the car started operation, and before any improvements had been made in it. His statements gave no inkling of the rapid progress made in this means for locating internal transverse fissures.

Believing that many of your readers will be interested in this phase of the subject, I submit a short summary of the first year of detector car operation.

The First Year of Fissure Detection

Just one year ago under the heading "Transverse Fissures Can Now Be Located" (*Railway Age*, November 17, 1928, page 959) there appeared a descriptive article on the Sperry detector car, together with an announcement that the car had just been placed in actual service by the American Railway Association.

When this car finally went into actual service after months of constant study and experiment, those responsible for its development had the feeling of a father watching his child take the first step. He knows the youngster is due for many a fall, but will have his sea legs long before the year is up. In the first few weeks of car operation many problems were encountered as was to be expected with an entirely new piece of apparatus, but the installation of various improvements ironed out these difficulties in a relatively short time.



The efficacy of these improvements was attested by Mr. W. C. Barnes (*Proceedings of the American Railway Engineering Association*, **30**, 1236, 1474, March 5, 6, 7, 1929) at the American Railway Association Convention last March just five months after the acceptance of the car.

"The car is being improved from week to week, additional apparatus and equipment are being put on which is improving the speed of detection and the accuracy of detection and the records now made are not at all comparable with those made in the beginning.

"On one road 18 rails in which fissures were detected were removed and immediately broken for verification and in each case a fissure was disclosed.

"With regard to accuracy, I should mention that we had a retest on a certain road for 85 miles going over the same track that was tested previously, and in all that 85 miles every flaw detected on the retest appeared on the original record with the exception of one. I think that is an extremely good record."

Since the above statements were issued other improvements and refinements have been and are being made from time to time.

With the completion of the American Railway Association's detector car, a second car was constructed to supply a testing service to the railroads desiring it. Four other cars have since been built and added to this service. Much valuable information has been obtained in this first year of car operation, however, as pointed out by Mr. C. W. Gennet, Jr. (*Railway Engineering & Maintenance*, **25**, No. 10, 432, October 1929).

"It would not be right even if it were possible, to give figures showing the number of fissures and other defects that the de-

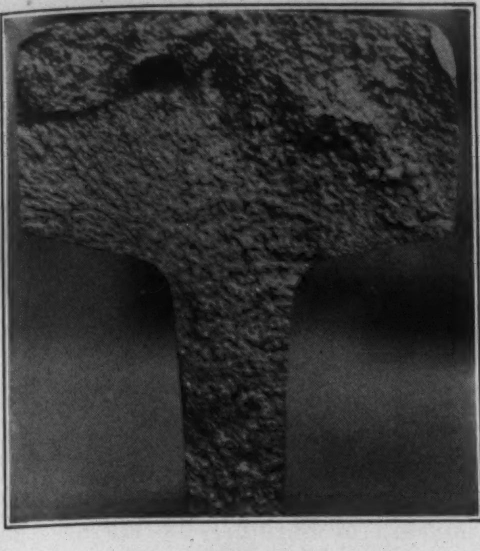


Fig. 1

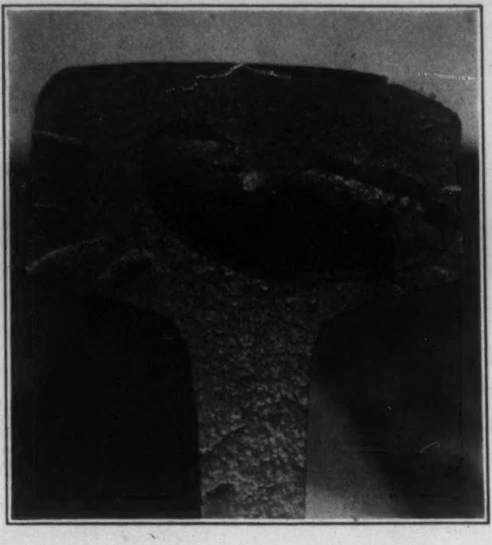


Fig. 2

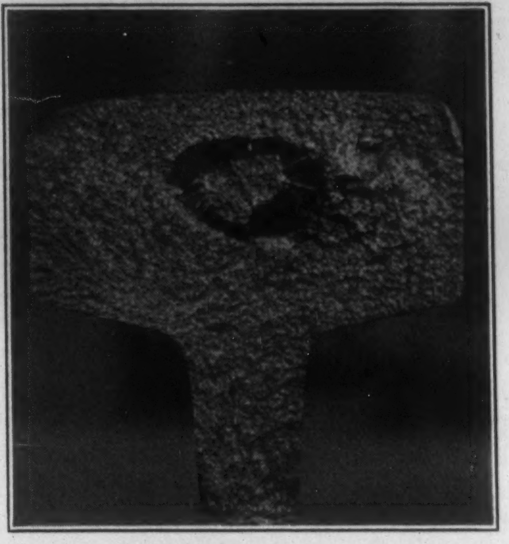


Fig. 3

tector cars find. Such figures in the hands of the uninitiated could do considerable damage, and naturally the confidence of the roads for whom we have done the work should be respected. Moreover, almost any set of figures obtainable might be misleading, for the fact remains that the detector car has generally been assigned to test suspicious track, meaning track presumably containing fissures because of experience and records. Thus, the detector car may only reach an infected locality and the number of fissures found may, therefore, be much greater proportionately than if the whole system had been tested. Notwithstanding the circumstances, I am taking the liberty of giving some results for practically 1000 miles of tested track on different lines with different kinds and ages of rail laid under different track conditions. On this mileage we found 116 transverse fissures, 66 horizontal fissures and 234 other defective rails. Thus, there was one transverse fissure in every 9 miles, 1 horizontal fissure in every 15 miles and 1 other bad rail in every 4 miles, or 1 seriously defective rail every 2.4 miles.

"To me the alarming phase of the whole situation is not with respect to the number of fissures and other defects found, but especially with respect to the size of some of the transverse fissures located. A great many rails are taken from track and broken immediately after the detector locates a fissure. Thus the awful truth is often revealed, and hence the frequent surprise that the defective rail gave safe passage to the last train."

In commenting on the first year's operation of the American Railway Association's detector car, Mr. C. W. Barnes (*Railway Engineering & Maintenance*, **25**, No. 10, 433, October 1929), Test Engineer of the Rail Committee, stated, "The detector car that is owned by the American Railway Association has tested 2200 track miles and in the course of this test an average of about 1 transverse or compound fissure has been detected by the machine per 10 miles of track. In addition to this, many other defects, including moon breaks in the base have been discovered.

"In a typical month the car covered 396 track miles or an average of about 14 miles per day. During this month no maintenance expense was required and the total delays for adjustments amounted to 40 minutes. A total of 195 rails were removed because of defects of which 46 were fissures."

As was to be expected the miles per fissure figure vary widely. In one case the average for more than 150 miles of track was 1 fissure for every 4 miles, while in other instances covering 50 mile sections of track, the figure has been a fissure for every $2^{1}/_{2}$ miles.

Fig. 4

In the first year of detector car operation more than 7000 miles of track were examined and the number of transverse fissures located and removed from track exceeded 600. This figure becomes more impressive when it is understood that the total number of reported rail failures last year due to transverse fissures, was 5400.

The car was primarily constructed for the purpose of locating transverse fissures, but it was immediately found that it also located split heads, pipes, horizontal fissures, crack webs, moon breaks, etc. Approximately 2000 defective rails of this type have been located within the past year. Many interesting rail defects have been encountered in the course of routine testing and a few of these are illustrated in the accompanying photographs.

The smallest fissure found in this first year of operation is illustrated in Fig. 1. This fissure has an area of 1.5% of the rail head and is considerably smaller than the nucleus of the fissure in Fig. 4. It appears to have started from a small longitudinal seam.

The large fissure in Fig. 2 also had its origin in a longitudinal crack, a large one. These fissures, together with many others of the same type clearly indicate that split heads, so-called horizontal fissures, and other longitudinal seams are potential nuclei for transverse fatigue failures.

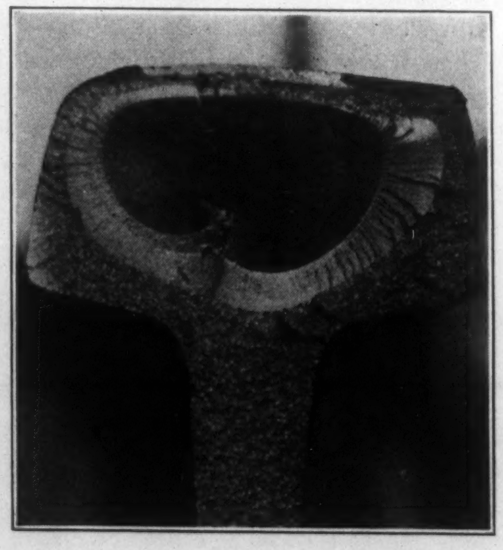


Fig. 5

The interest in Fig. 3 centers round the nucleus. This nucleus is considerably larger than the average, having an area of 5.3% of the rail head. It is 3.5 times larger than the little fissure shown in Fig. 1.

The incipient split head illustrated in Fig. 4 is representative of a large number of defective rails located in the past year by the detector cars.

Photograph Fig. 5 illustrates a typical large fissure that has almost severed the entire rail head. It has the peculiar ringed pattern found on many fissures and termed by some growth rings.

The transverse fissure type of rail failure has been known for the past 18 years but in that period very little information has been obtained regarding the rate of fissure growth. It is known that in heavy traffic the growth is more rapid than in light traffic lines, but that is about the extent of the information. The Sperry detector car now makes it possible to obtain an accurate daily record of the growth of fissures in track. Such a record together with data covering tonnage, train speeds, road bed conditions, and other pertinent facts obtained on the track under observation, would make possible a comprehensive study of the speed of fissure growth and the various factors governing that growth.

Very truly yours,
HARCOURT C. DRAKE,
Chief Engineer

Sperry Development Company, Inc.,
Manhattan Bridge Plaza,
Brooklyn, N. Y.

A Study of Barium-Tin Alloys

By K. W. Ray[1] and Ralph G. Thompson[2]

Introduction

A review of the literature reveals that little work has been done on barium alloys. J. L. Gay Lussac and L. J. Thenard[3] heated a mixture of baryta, charcoal and tin but failed in preparing the barium alloy. H. Caron[4] heated sodium carbonate, barium chloride, carbon and finely divided tin until sodium vapors were no longer evolved. He claimed to have obtained an alloy that was brittle and also harder than tin. W. Mathesius and H. Mathesius[5] prepared an alloy containing lead, barium, strontium and calcium. In their process an alloy of lead, calcium and sodium was first made by causing metallic sodium to react with a layer of calcium chloride on a bath of molten lead. The layer of chloride was then removed and replaced by a layer of strontium and barium chlorides, whereupon strontium and barium replaced some of the calcium and sodium in the alloy. A lead alloy containing 2% calcium and 1% each of strontium and barium was so prepared.

Several alloys of barium and lead have been made and and studied, and a part of the thermal diagram of this system has been investigated.[6] Several barium-lead alloys have been patented as bearing metals. One of the most successful of these is Frary metal.[7] This alloy is made by the electrolysis of a fused mixture of calcium and barium chlorides with molten lead as the cathode. The alloy contains from 0.5–2.0% barium and from 0.25–1.0% calcium.

A barium-tin alloy of low barium content has also been made electrolytically at Columbia University.[8]

K. Jellinek and J. Wolff[9] have prepared electrolytically alloys of tin with barium and potassium. They also prepared alloys of lead, bismuth and antimony with alkali earth metals. The purpose of their investigation was to study the equilibrium conditions existing between the alkali and the alkali earth metals and their fused salts, such as is shown in the equation:

$$Ba + 2KCl = BaCL_2 + 2K.$$

Their apparatus consisted of a fire-clay crucible through the bottom of which a metal rivet was electrically welded. This served as a connection to the molten metal which was made the cathode in the electrolysis. A carbon electrode placed in the salt bath served as the anode. The crucible and contents were heated in a gas-fired furnace. Barium was deposited at the cathode and it alloyed with the molten metal, while chlorine was given off at the anode. They showed that when a mixture of barium chloride and potassium chloride was electrolyzed, some potassium was deposited with the barium, but the amount was small and was influenced by the composition of the original mixture. They found that about 0.2% potassium was deposited when the salt bath contained 57.8 molar percent potassium chloride.

K. W. Ray[10] has also investigated the electrolytic preparation of barium and strontium alloys. He found that metallic crucibles could be used in many cases instead of those of porcelain or fire-clay.

In most of the work done in the past on barium alloys, the chief interest seems to have centered around the method of preparation rather than the properties. Furthermore, very few barium-tin alloys have been prepared, and it seems that the thermal diagram has never been studied.

It was, therefore, the purpose of this investigation to prepare a large number of barium-tin alloys, to study their physical properties, and to construct, if possible, the thermal diagram.

Laboratory Methods

The barium-tin alloys were produced by the electrolysis of a eutectic mixture of potassium chloride and barium chloride over molten tin in a chromium plated iron crucible. The molten tin was made the cathode and a carbon electrode which extended into the salt bath, served as the anode. (Fig. 1) On electrolysis, chlorine was given off at the anode while barium was deposited at the cathode.

It was necessary to use a chromium plated crucible because the tin alloyed readily with nickel or iron crucibles. Since chromium does not alloy readily with tin, and apparently not with barium, it was found that by electroplating an

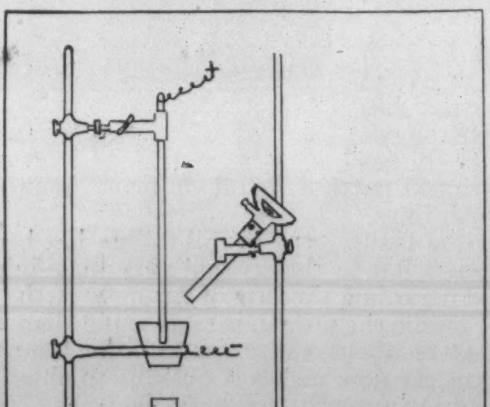


Fig. 1. Apparatus Used in the Preparation Barium-Tin Alloys

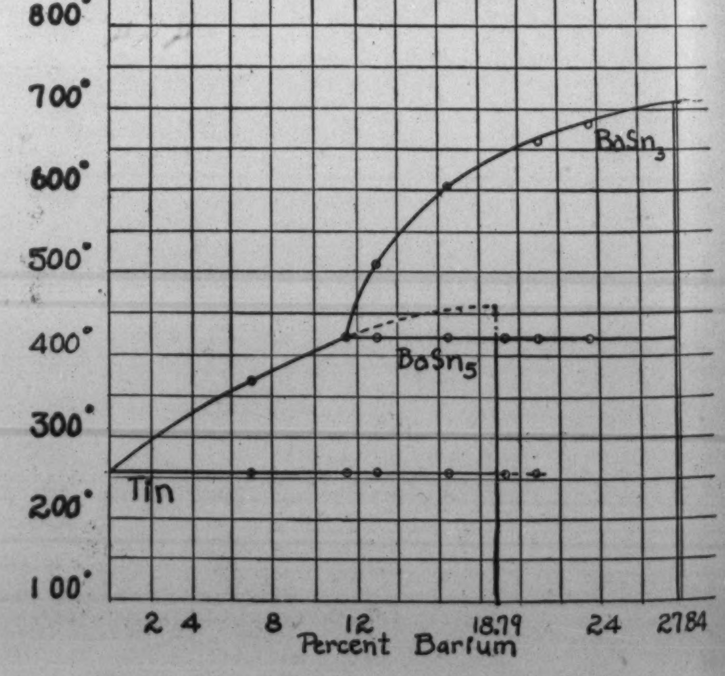


Fig. 2. Thermal Diagram of Barium-Tin (Table 1)

iron crucible on the inside with chromium, a very durable crucible was obtained, and that the alloys prepared in it contained no appreciable amounts of chromium. The crucible was electroplated in a bath containing 300 grams of chromium trioxide and 3 grams of chromium sulphate per liter. A lead rod was made the anode, while the crucible served as the cathode. A current density of 20 amperes per square decimeter for four hours gave a heavy plate of chromium. The temperature of the bath was near the boiling point.

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[1] Associate in Metallurgy, Department of Chemistry, University of Iowa.

[2] Revised from the thesis submitted by Ralph G. Thompson in partial fulfillment of the requirements for the M. S. degree.

[3] *Recherches physicochimiques*, Paris, 1811.

[4] *Compt. Rend.*, **48,** 440 (1859).

[5] Brit. Pat., 186,124, Aug. 24, 1922.

[6] *Zeit. für Metallkunde*, Oct. 1920.

[7] *Chem. Met. Eng.*, **25,** 1181 (1920).

[8] *Trans. Am. Electrochem. Soc.*, **40,** 15 (1921).

[9] *Zeit. Anorg. Chem.*, **146,** 329 (1925).

[10] Metals & Alloys, **1,** 112 (1929).

The preparation of the barium-tin alloys was carried out at about the lowest temperature at which the contents of the crucible could be kept liquid. The eutectic composition of the bath, which was 30% potassium chloride and 70% barium chloride by weight, was used since this gave a much lower melting salt bath than pure barium chloride would have given. After this electric preparation, the alloys were remelted under a bath of pure barium chloride in order to remove the small amount of potassium they contained.

In taking the cooling curves, a 50-gram sample of the alloy was melted in a pyrex test tube in a cylindrical electric furnace. A few drops of kerosene were added to the test tube to prevent the oxidation of the sample. On evaporation, the kerosene removed practically all of the air and left an atmosphere composed mainly of hydrocarbons. It was undesirable to use hydrogen, carbon dioxide, carbon monoxide or nitrogen, since these reacted with the barium.

The cooling curves were recorded by a Brown recording pyrometer which had a resistance of 265 ohms.

The composition of the alloys was determined by chemical analysis. A modified method of K. Jellinek and J. Wolff[11] was used. This consisted in placing a weighed sample in an Erlenmeyer flask which contained mercury and water. The tin amalgamated with the mercury, and the barium reacted with the water to form barium hydroxide and hydrogen. The solution was boiled for about one hour to aid in the decomposition of the alloy. When hydrogen was no longer evolved, the solution was cooled and titrated using standard hydrochloric acid and sodium hydroxide which had previously been standardized against a Bureau of Standards sample of potassium acid phthalate. The tin was calculated by difference.

The hardness of the alloys was determined by both the Rockwell and the Shore Scleroscope hardness testers. A one-fourth inch steel ball, the 100-kilogram weight and the "B" scale were used on the Rockwell machine. Most of the samples were too brittle to be tested on the Brinell.

In annealing the alloys for microscopic examination, the samples were sealed in a glass tube to prevent oxidation and were then heated at 400° C. for about 12 hours. After grinding and polishing, the alloys low in barium were etched in a solution of alcohol and ether, while the higher barium alloys were exposed to the air for a few moments and then given a thin coating of oil to prevent further reaction with the moisture in the air.

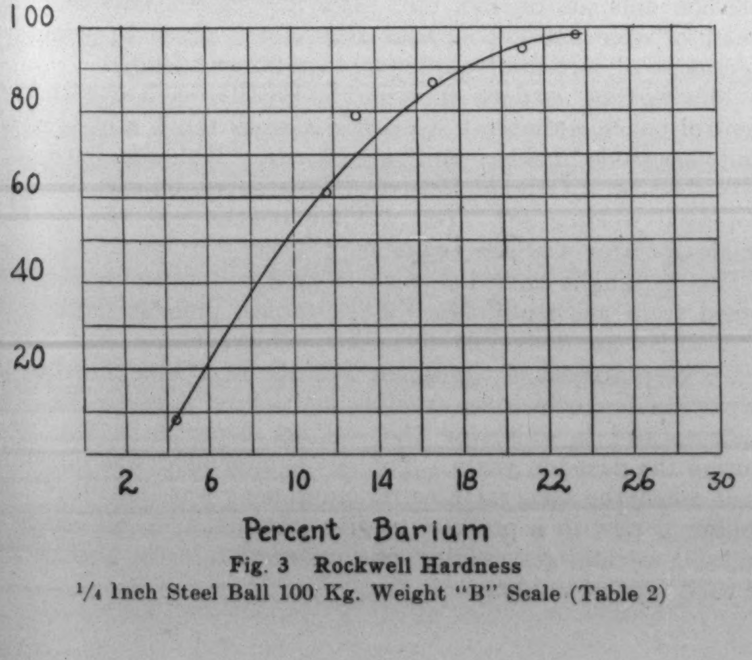

Fig. 3 Rockwell Hardness
1/4 Inch Steel Ball 100 Kg. Weight "B" Scale (Table 2)

Results

The thermal analysis of barium-tin alloys containing 28% or less of barium showed that two intermetallic compounds are formed, $BaSn_3$ and $BaSn_5$. Compound $BaSn_5$ is unstable above 422° C. and changes into $BaSn_3$ and tin. Table 1 gives the temperatures corresponding to the breaks recorded in the cooling curves.

Table 1—Cooling Curve Data of Barium-Tin Alloys

Percent Barium	Initial Appearance of $BaSn_3$	Initial Appearance of $BaSn_5$	Separation of Pure Tin
30	710° C.		
23.54	682° C.	422° C.	
20.91	658° C.	422° C.	232° C.
19.31	595° C.	422° C.	232° C.
16.45	605° C.	422° C.	232° C.
12.97	510° C.	422° C.	232° C.
11.53		422° C.	232° C.
6.95		365° C.	232° C.

These results, together with the microscopic evidence, indicated that the compound $BaSn_3$ was the only solid phase which was stable above 422°, and that in alloys containing less than 18.79% barium, $BaSn_5$ was the only solid phase stable between the melting point of tin and 422°. Since considerable time was required for the solid $BaSn_3$ to combine with all of the liquid tin and change into $BaSn_5$ on cooling to the transition temperature, some of the cooling curves of the alloys containing more than 18.79% barium gave three breaks instead of the two expected. However, microscopic examination showed that complete equilibrium had not been reached since the three phases $BaSn_3$, $BaSn_5$ and tin were all present. Upon annealing these alloys, the tin phase always disappeared leaving only the two compounds. The composition of the compounds was determined by the lengths of the arrests at 422° as well as by microscopic study of the annealed alloys.

The properties of the barium-tin alloys were found to be very different from the properties of pure tin. They corroded very rapidly in air to form a film of oxide and carbonate. Further corrosion then took place much more slowly. The alloys high in barium would sometimes become incandescent when powdered in a mortar. The alloys also decomposed water with the evolution of hydrogen.

The hardness of the alloys increased rapidly with an increase in the barium content. Table 2 and Fig. 3 show the hardness values obtained. The malleability also decreased rapidly,

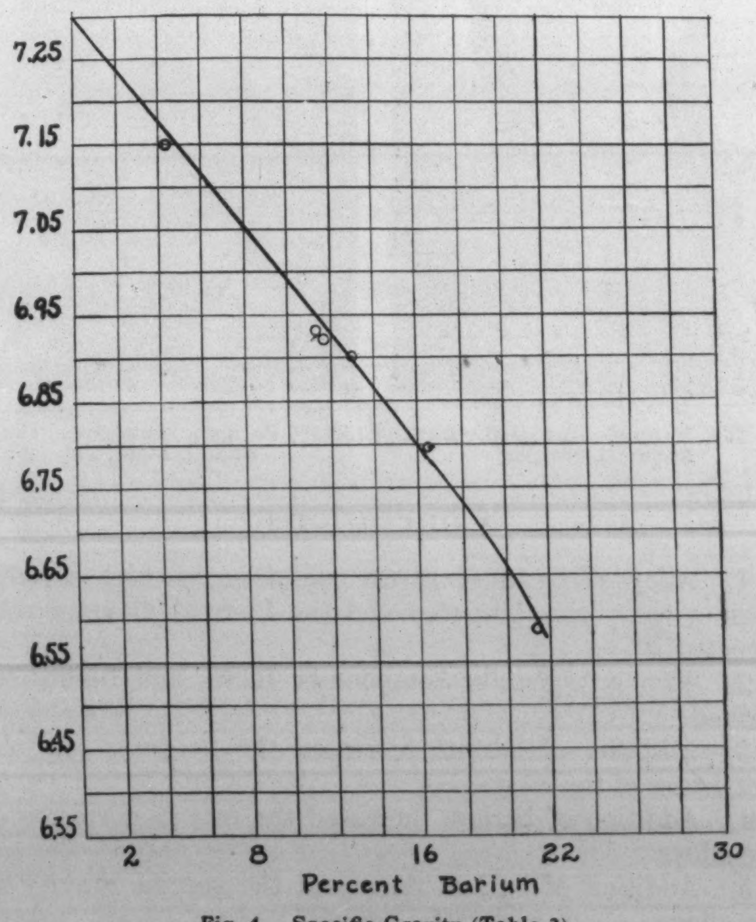

Fig. 4. Specific Gravity (Table 3)

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[11] *Z. Anorg. Chem.* **146,** 329 (1929).

Table 2—Hardness of Barium-Tin Alloys

Percent Barium	Rockwell hardness ¼ Inch Steel Ball 100 Kg. Weight; "B" Scale	Scleroscope Hardness
4.41	8	6
11.67	61	15
12.97	79	21
16.67	87	23
20.96	95	28
23.54	98	30

Table 3—Specific Gravity of Barium-Tin Alloys

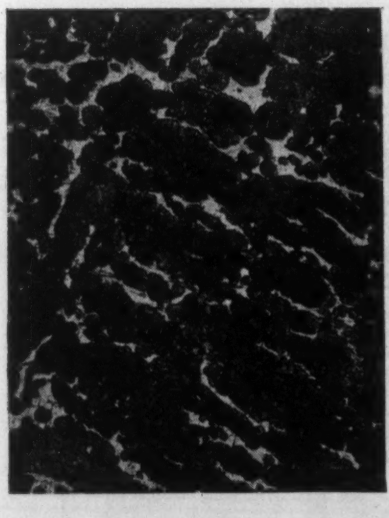
Percent Barium	Actual Specific Gravity	Calculated Specific Gravity	Percent Contraction
4.41	7.15	7.13	0.00%
11.37	6.87	6.93	0.87%
11.67	6.86	6.92	0.87%
12.98	6.80	6.90	1.44%
16.67	6.67	6.80	1.94%
21.38	6.49	6.58	1.07%

and alloys containing more than 16 percent were so brittle that they could be powdered in a mortar.

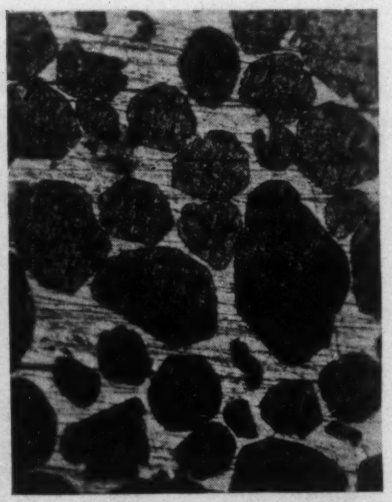
The addition of barium decreased the specific gravity of the alloys. Table 3 gives the specific gravity for various percentages of barium. The theoretical values were calculated by taking the specific gravity of cast tin as 7.3 and of barium as 3.5.

20.91% Barium. Annealed. Dark, $BaSn_3$; Light, $BaSn_5$

23.50% Barium. Annealed. Dark, $BaSn_3$; Light, $BaSn_5$



16.56% Barium. Annealed. Dark, $BaSn_5$; Light, Tin



13.13% Barium. Annealed. Dark, $BaSn_5$; Light, Tin

Conclusions

1. Alloys of barium and tin containing as high as 30% barium have been prepared and the thermal diagram constructed.

2. Two intermetallic compounds, $BaSn_3$ and $BaSn_5$, are formed.

3. Addition of barium increased the hardness and the brittleness of the alloys.

4. Addition of barium increased the rate of corrosion of the alloys.

5. Addition of barium decreased the specific gravity of the alloys.

N. Y. Section, American Society for Steel Treating

The New York Section of the A. S. S. T. meets in New York, Hotel Pennsylvania, February 7 and 8, 10:00 a.m. and 2:30 Saturday, and 10:00 a.m., Friday. The program is as follows:

Friday a.m.—February 7.—"Nickel Alloy Steel Forgings," C. McKnight, International Nickel Co. "Effect of Cr Additions to Mn Structural Steels," A. B. Kinzel, Carbide & Carbon Research Laboratories.

Friday p.m.—February 7.—"Grain Structure in Martensite," E. C. Bain & K. Heindlhofer, U. S. Steel Corporation Research Laboratories. "Study of the Nitriding Process—The Simultaneous Introduction of N and C," V. O. Homerberg & J. P. Walsted, M. I. I.

Saturday a.m.—February 8.—"Recent Developments in Normalizing Sheet Steel," S. S. Lawrence, Duraloy Co. "Notes on Sheet Metal and Strip Steel for Automobile Bodies," J. Winlock & J. L. Kelley, Budd Mfg. Company. "Medal for Vitreous Enameling," J. H. Nead, American Rolling Mill Company.

Metallurgical Uses of Natural Gas

The probability that the development of metallurgical uses for natural gas may stimulate the growth of chemical and metallurgical industries on the Pacific Coast is suggested by the United States Bureau of Mines, Department of Commerce. The Pacific Experiment Station of the Bureau of Mines, located at Berkeley, California, has recently had many requests for information concerning possible metallurgical uses for natural gas or methane. The thermodynamic investigations of the properties of metallurgically important materials being conducted at that station have been particularly useful in enabling such inquiries to be met in a helpful manner.

It seems possible that for strictly metallurgical or chemical uses, that is, aside from the use for direct production of power, the fields of greatest theoretical interest will be the manufacture of hydrogen for ammonia syntheses, and the direct reduction of such oxides as zinc or iron. Although the direct manufacture of hydrogen from methane is possible, it seems that the most economic method for producing the pure hydrogen required for ammonia syntheses will be by the action of steam on metallic iron, the iron oxides so produced being again reduced to metal by the use of the natural gas.

The thermodynamic properties of methane are such as to cause it to be very efficient as a reducing agent for oxides. Although at very low temperatures methane is theoretically a poorer reducer than a mixture of the carbon and hydrogen which comprises its composition, it rapidly becomes a more active reducer at such relatively low temperatures as 600–700° C.

Carnegie Tech. Has Largest Welding School

The Carnegie Institute of Technology now has the largest school for the training of welders of any college in the United States. New equipment, recently installed, enables this institution to handle the largest classes in welding in this country.

The classes at Carnegie consist of two groups, one to teach skill in welding, considering the torch and electrode as tools, and the other to teach the young engineer the possibilities of welding.

The night classes in welding have an enrollment of over 250 students. Instruction is conducted to perfect skill and to give some idea of the reasons for fusion of metals, penetration, expansion and contraction, etc. The day classes have an enrollment of over 350 and special attention is given to structural, aeronautical, automotive, pipe and container welding.

The welding is done in separate booths, each containing a control panel, a rheostat, a reactor, a work table, a head shield, and electrode holder and accessories. Welding current is furnished by a General Electric 1000-ampere, 60-volt constant-potential welding set. Ten welding booths and two portable single-operator sets are available.

Gas welding is carried on with 16 modern torches conveniently piped from gas manifolds. Work tables, preheat muffles and accessories are available for each welder.

To keep abreast of the times, Prof. S. E. Dibble, head of the department in which the welding instruction is given, has been instrumental in enlarging the welding department five times during the past ten years. The last enlargement was made this year when the General Electric equipment was installed. The college is now in a position to give instruction in all classes of metallic arc and gas welding, and instruction in the applications of each type of welding.

Metals Used in Aircraft Construction[1]

By Prof. Bradley Stoughton[2]

Aircraft are comprised under:

A: Craft heavier-than-air, namely: airplanes, seaplanes, flying boats, helicopters, etc. and
B: Craft lighter-than-air, such as: balloons, rigid dirigibles, non-rigid-dirigibles, semi-rigid-dirigibles, etc.

To the evolution and improvement of both of these types, metallurgical developments have generously contributed. Commander Jerome C. Hunsacker, U. S. N., says,[3] "To a degree little realized, the Zeppelin airship must be classed as a contribution of the metallurgist." While the same situation exists as regards heavier-than-air craft, whether it exists to the same degree or not is not for us metallurgists to say. Certain it is that improvements in man's understanding of metals, of alloys and of the treatment and adaptation of the properties of metals has done a great deal to make the modern airplane possible; but improvements in design and in mechanical engineering and power features must also receive a large share of the credit. The three greatest enemies with which metals must contend are: Abrasion, or wear, which, in an engine, means loose bearings and consequent short life; fatigue, or failure under vibration (or any dynamic load) at a stress which would be quite safe for any static load; and corrosion, or staining and rusting. When corrosion occurs in the presence of a fatigue strain, the life of a metal may be much reduced—a study which is receiving attention from Dr. D. J. McAdam, Jr., at Annapolis, and others, with results of considerable importance. Lesser enemies, because they affect a fewer number of parts, are: High temperature (red heat), such as in spark plugs, valves, pistons, etc., which tends to cause loss of strength, scaling, softening or even melting; and shock, or sudden strains, as in transmission parts, gear teeth, structural parts in emergencies, etc. How well metals have been groomed to resist these enemies is indicated by the fact that, with refueling, with changing spark plugs in the air, and with temporary protection of exposed parts with selected grease, or the like, the endurance of the metal parts of an airplane is now greater than the endurance of human beings against fatigue.

Metals Versus Non-Metals

The present tendency is to make all air-craft 100% metal, even to the smallest details. This is because of less hazard in fire or accident, greater strength-weight factor (see Table I), more efficient joining, imperviousness to moisture, and ductility. Some prefer wood in a few parts—for example, propellers, which are more noisy if made of metal—but others scrupulously avoid organic materials, because of danger of inhomogeneities, such as knots, hidden decayed spots, etc. Some governments have now ruled against any inflammable materials in aircraft for war. Metals are chemical elements, the simplest substances known to science; they alone possess true ductility, without which a structure cannot adjust itself to slight changes in dimensions necessary before a body can act as a single unit to resist strain. Ductility also enables a body to contend with an "irresistible force" without necessarily complete collapse, such as a violent tornado. This has been illustrated more than once when steel buildings have stood up in earthquakes which have destroyed wooden buildings—even bamboo huts in Japan. It is not my intention to discuss in detail the evolution of aircraft from the wooden structures which prevailed in this country until after the War, through various types of construction to the most modern approved materials, because others have covered this development, notably Horace C. Knerr.[4] The great confusion which existed when all types of alloys were demanded for a great variety of purposes, was simplified through a conference of the U. S. Army and Navy Aeronautical experts, by which a simplification and standardization was effected. This has been a great boon to both aircraft makers and those who supply them with metals. Of almost equal benefit to the industry are the published specifications of the U. S. Army Air Corps. In making up the accompanying Tables of Analyses and Physical Properties, I have used these published data very freely, and wish to acknowledge the kind permission to use them as well as to pay a tribute to their usefulness and completeness.

Importance of the Strength-Weight Factor and the Form Factor

Knerr has given us a slogan to the effect that "in aircraft construction every ounce of weight must justify itself." In illustration of this he quotes the figures given in Table I, which are slightly augmented and amended from his data. This "strength-weight factor" gives a figure expressing the relative amount of strength obtainable from an equal weight of the different substances there shown, when suitably treated and designed. At a glance we can see the value of high-tension wires used for interior bracing of rigid dirigibles and for the structural bracing of airplanes. It is also clear that aircraft of given carrying-power, strength and efficiency (and greater safety) can be made of less weight from metal than from wood. We may also see one of the reasons why alloy steels have in some cases replaced non-ferrous alloys for structural parts. Many facts can be gathered from this table by study. Nevertheless, the table does not tell the whole story, because other considerations enter into the choice of aircraft materials, such as: resistance to heat, corrosion, fatigue, shock, abrasion, ease, reliability and economy of fabrication, and, finally, the so-called "form factor." For example: A sheet of alloy steel might be as thin as paper and still be as strong as a duralumin sheet three times as thick, but the steel sheet would be flimsy, while the duralumin sheet would add stiffness and stability as sheathing for a dirigible gas bag, or wing-covering for an airplane. Chiefly because of the importance of this "form factor" dural-

Table I—Typical Strength-Weight Factors[a] of Aircraft Materials

Wrought metals (tension)		S. W. F.[a]
Music wire[b]—0.01 inch in dia...	400,000/7.85	= 51
Alloy steel[c]—high	150,000 to 200,000/7.85	= 19 to 25
Duralumin[c]	55,000/2.85	= 19
Magnesium alloy[c]	25,000 to 45,000/1.80	= 14 to 25
Alloy steel[c]	100,000 to 125,000/7.85	= 12.7 to 16
Mild steel—normalized	55,000/7.85	= 7.0
Aluminum—annealed	12,000 to 18,000/2.7	= 4.4 to 6.7
Monel metal	85,000[d] to 140,000/8.8	= 9.7 to 16
Wood (compression)		
Balsa	2200/0.12	= 18
Douglas fir	6000/0.54	= 11
Spruce	4300/0.43	= 10
Oak, white	5900/0.74	= 8

[a] Obtained by dividing ultimate strength in thousands of pounds per square inch by specific gravity.
[b] Cold drawn, or cold worked.
[c] Heat treated.
[d] Hot rolled or forged.

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[1] A paper presented before the Society of Chemical Industry.
[2] Lehigh University, Bethlehem, Pa.
[3] *The Technology Review*, May 1929.
[4] See especially "Aircraft Metallurgy," by H. C. Knerr, in *Aviation Engineering*, March and April 1929, et al.

umin is the present standard American material for covering dirigibles. It is used on ZMC-2 recently built in Detroit and the two giant dirigibles being built for the United States by the Goodyear Zeppelin Company. For this use the dural is covered on both sides with a thin film of pure aluminum, to protect it from corrosion.

Structural Parts Versus Propulsion Parts

For structural parts of aircraft we require not only a high strength-weight factor, but also good *elastic* strength, resistance to corrosion, and some parts also require stiffness. For the propulsion parts, in which we include the engine, transmission mechanism, propeller, etc., we prefer a high strength-weight factor; some parts must also resist fatigue and impact; others must resist heat. We shall therefore discuss separately the metals used for structural purposes and those used for propulsion in aircraft.

Metals Used for Structural Purposes

As wood gave place to metal construction in aircraft, developments proceeded along two separate lines: Aluminum alloys of light weight and high strength were developed first, and rapidly replaced wood, because of their better strength-weight factor and greater reliability. The alloy especially used was the so-called "duraluminum," or "dural," produced first in Germany and containing about 94% Al, 4% Cu and 1% each of manganese and magnesium. It has a specific gravity about one-third that of steel. It has certain drawbacks, however: Its corrosion proved to be sometimes serious,[5] especially in seaplanes; it was not easy to work, because it endured cold working only for about 45 minutes after fresh quenching; if riveted, it tended to corrode in the rivets; if welded, it corroded at the weld and was tender; it was costly to make and to heat-treat. On the other hand, its form factor was in its favor as compared to steel. Dural is not the best aluminum alloy for castings, because its best properties are brought out by a heat treatment to which castings cannot always be subjected. In Table II are given a number of analyses, heat treatments and physical properties. These are all alloys used at the present time in approved construction practice. The meaning of the terms, "annealing," "solution heat treatment," "precipitation heat treatment," as applied to these alloys may be learned from the book "Strong Aluminum Alloys" quoted in Table II.

Speaking parenthetically we may say that, in an attempt to learn what metals were used in American aircraft manufacture, we addressed a letter to 108 American manufacturers of airplanes and parts, asking them for their specifications for materials used. Answers were received from several

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[5] Dural does not corrode as badly if it is quenched in cold water as it does when quenched in hot water.

Table II—Aluminum and Its

	Chemical Analysis											
Reference	Al, %	Cu, %	Si, %	Mn, %	Mg, %	Zn, %	Ni, %	Fe, %	Tota Impurities	Name		Annealing, ° F.
U. S. A. 57-15-A	99.0^a	....	Note B					Note B	1.05^+	U. S. Army Grade A Note Y		
U. S. A. 57-15-A	98.0^a	....	Note A					Note A	2.00^+	U. S. Army Grade B		
U. S. A. 57-15-1	99.5^a	0.10^b	Note C					Note C	0.50^+	U. S. Army Grade AA		
Iron Age, 9/5/29, page 615	97.0			1.25								
U. S. A. 98-10026	92^a	3.5–4.5		0.4–1.00	0.2–0.75					Duralumin $17S^d$	Bar Note W	625–700
U. S. A. 57-152	92^a	3.5–4.5		0.4–1.00	0.2–0.75					Durulamin $17S^d$	Sheet *aa*	625–700
U. S. A. 57-187	92^a	3.5–4.5		0.4–1.00	0.2–0.75					Duralumin $17S^d$	Tube	625–700
U. S. A. 57-153	92^a	3.5–4.5		0.4–1.00	0.2–0.75					Duralumin $17S^d$	Bar	625–700
U. S. A. 98-10026	92.5^a	4–5	1.20^b	0.4–1.00		0.25^b		0.75^b		Duralumin $17S^d$		
U. S. A. 57-72 Grade 6	87.0^a	9.25–10.75			0.35^b	0.2^b		1.00–1.50		Duralumin casting		
U. S. A. 57-72 Grade 3	92.5^a	4–5	1.20^b	0.35^b		0.25^b		1.20^b		Duralumin casting		
U. S. A. 57-72 Grade 1	90.0^a	3.75–4.50	0.5^b	1.25–1.75		0.20	1.75–2.25	0.75^b		Note Z—Casting		
"Strong Aluminum Alloys" Published 1928 by Aluminum Co. of America	96.5^a		1.0		0.6					51S	$51\text{-}SO^e$ $51\text{-}SW^e$ $51\text{-}ST^e$	650 bb 650 bb 650 bb
	95.0^a	2.5			0.3					$A17S^d$ Duralumin	$A17SO^e$ $A17ST^e$	650 bb 650 bb
	94.0^a	3.5			0.3					$B17S^d$ Duralumin	$B17SO^e$ $B17ST^e$	650 bb 650 bb
	93.0^a	4.5								195 Casting		650 bb 650 bb 650 bb
	92.0^a	4.5	0.8	0.8						$25S^d$	$25SO^e$ $25SW^e$ $25ST^e$	650 bb 650 bb 650 bb
	92.0^a	4.0	1.25	0.5	0.5					C-17S(special 17S)	$C\text{-}17SO^e$ $C\text{-}17SW^e$ $C\text{-}17ST^e$	650 bb 650 bb 650 bb
	92.0^a	4.0		0.5	0.5					$17S^d$ Duralumin	$17SO^e$ $17ST^e$	650 bb 650 bb
Iron Age, 9/5/1929, page 615	92.0	4.0		0.5	0.5					Alclad—Note X		
Bossert, Sept. 1929, *Trans. Am. Electro.-Chem. Soc.*	92	8								No. 12 Casting		
	95		5							No. 43 Casting		
U. S. Army 98-10026	10.25–12.25	82^a			0.15^b	0.25^b		2.5–3.5		Aluminum bronze		
U. S. Army 98-10026	10.25–12.25	76^a			0.15^b	0.25^b	4.5–5.5	4.5–5.5		Aluminum bronze		

[a] Minimum. [b] Maximum. [c] Fe, Si, Mn, Cu, etc.—Maximum. [d] The alloy called Duralumin and Alloy 17S are almost identical in limits of chemical

of those addressed, from which we learned: The Army and Navy Departments and a few of the outstanding manufacturing concerns give most careful and expert attention to metals used. But a large number of the manufacturers seem to be either ignorant or careless about the type of materials best suited for aircraft structural purposes, like a temporarily successful business man who discounts the future by being careless about his health. We are forced to believe that this type of aircraft manufacturer will go the way of so many early automobile manufacturers who built cars for a while and then disappeared from sight. A third point brought out by the answers received was that many manufacturers did not make their own engines, but bought them from established aircraft-engine makers, who, from their answers, were giving careful thought to the metals best suited for the service needed, although, in a few cases, sacrificing the top-notch of quality for the sake of economy. This question will be better understood in the discussion of metals used for propulsion purposes.

The second line of development in aircraft construction was in alloy steels. The kinds of steel used have undergone some change, and the ones now frequently used are: Nickel steel, for which see Table IV; this steel has a high quality factor,[6] a high strength-weight factor, is tough, but somewhat high in price. Chrome-nickel steel (see Table III) has a slightly less quality factor,[6] laminates less and costs less than 3½% nickel steel; Chrome-vanadium steel (Table III) has several high qualities and is probably now used more than either plain nickel steel or chrome-nickel. But the steel which at present seems to be most esteemed by the manufacturers, at least, is the chrome-molybdenum steel shown in Table III, especially because of its easy and reliable welding and fabrication; also because it draws into tubes better than chrome-vanadium steel. It is said that chrome-molybdenum steel, in the form of streamline tubes, etc., is now used for fuselage construction more than any other material, including dural. Further details concerning all these structural steels, including their analysis, treatment and properties, will be evident from a study of Tables III and IV.

For structural parts requiring severe cold work, such as deep cupping and drawing, cold forming of fittings, etc., low-carbon steel is used in preference to the harder alloy steels, especially as these small parts do not add much to the weight of the craft. (See Table V.) Other non-bulky parts, such as springs, are also sometimes made of high-carbon steel, but, for this purpose, the more efficient and resilient chrome-vanadium or silico-manganese steels are used. (See Table III.) High tension wires are also commonly made of plain steel whose carbon is 0.80–0.85%,

Alloys for Aircraft Construction

Heat Treatment Hardening—Note E Temperature °F.	Soaking Time, Mins.	Quenching Water (W) Air (A)	Ageing—Note D Temp. °F.	Time Hours	Physical Properties Tensile Strength Minima	Yield Point Lb./Sq. In. Minima	Elongation, % in 2″	Hardness 500 kg. Brinell Average	Shore Minima	
					12,000–16,000 22,000–30,000		30–45 4–1			Note A—Si max. 0.50. Fe + Si max. 1.50%. Note B—Fe max. 0.50. Fe + Si max. 1.50%. Note C—Fe + Si max. 0.40. Note D—Aging effected by heating is called "Precipitation Heat Treatment." Note E—This is also called "Solution Heat Treatment."
					15,000–18,000 27,000–35,000		15–30 4–1			
925–960	10–120	W at 60° F.	200–300	2	55,000	25,000	18	90	20	aa. 57-152-2 Coated on both sides by pure aluminum. Excellent resistance to salt spray corrosion, but physical properties are slightly lower—called "Alclad." See Alclad below.
925–960	10–120	W at 60° F.	200–300	2	55,000	30,000	12		20	
925–960	10–120	W at 60° F.	200–300	2	55,000	30,000	16			
940–970	120	W at 60° F.	210–350	10–20	55,000	25,000	18	90		bb. To anneal, heat these alloys to 650° F. and allow to cool. Special annealing required for 17ST—i. e., heat to 800° F. and cool very slowly in furnace to 450° F.
940–970	240	A or W	385–415	1	30,000			100		cc. If heated in a nitrate bath.
940–970	16–24 hr.	W at 60–212° F.	285–315	2	30,000		3	70		
940–970	240	A or W	385–415	1	32,000			90		
970	25 ± cc	Cold W. dd	310–320	18	14,000–19,000	4,000–6,000	22–32	25–32		dd. If quenched in cold water, the product has higher resistance to corrosion than if hot water is used.
970	25 ± cc	Cold W. dd	310–320	18	30,000–40,000	15,000–20,000	20–30	55–70		
970	25 ± cc	Cold W. dd	310–320	18	45,000–50,000	30,000–40,000	10–18	90–100		
940–960	25 ± cc	Cold W. dd			20,000–25,000		20–28	30–40		25S for forgings.
940–960	25 ± cc	Cold W. dd			35,000–45,000	15,000–20,000	20–28	55–75		25S Propeller blades. Will bend but not break.
940–960	25 ± cc	Cold W. dd			20,000–25,000		20–28	30–40		
940–960	25 ± cc	Cold W. dd			42,000–50,000	20,000–25,000	20–28	65–85		51ST for crankcase.
Al. Co. of Am.		HT No. 4			28,000–38,000	13,500	6–12	65		Note Z—Used for pistons, air-cooled cylinder heads, bearing surfaces, and other high temperature purposes. Specific gravity = 2.90.
Al. Co. of Am.		HT No. 16			30,000–40,000	21,000	3–8	75		
Al. Co. of Am.		HT No. 10			36,000–50,000	27,000	0–5	100		
970	25 ± cc	Cold W. dd	285–295	8–15	23,000–35,000	7,000–12,000	12–20	45–55		
970	25 ± cc	Cold W. dd	285–295	8–15	45,000–53,000	15,000–30,000	15–22	68–85		Note Y—Aluminum tubes for gas, oil and water lines, also for aluminum, gasoline and oil tanks. May be enameled against hot water and gasoline. See U. S. Army Air Corps Spec. 3-135.
970	25 ± cc	Cold W. dd	285–295	8–15	55,000–63,000	30,000–40,000	16–25	90–105		
920–940	25 ± cc	Cold W. dd	310–320	18	25,000–35,000	7,000–10,000	12–20	42–55		
920–940	25 ± cc	Cold W. dd	310–320	18	55,000–63,000	30,000–40,000	18–25	90–105		
920–940	25 ± cc	Cold W. dd	310–320	18	63,000–70,000	50,000–55,000	8–14	95–125		
920–940	25 ± cc	Cold W. dd			25,000–35,000	7,000–10,000	14–22	45–55		Note X—Alclad is used for wing coverings, sheet for dirigible gas bags, structural parts and all parts requiring strength and resistance to corrosion.
920–940	25 ± cc	Cold W. dd			55,000–63,000	30,000–40,000	18–25	90–105		
					50,000–58,000	27,000–36,000	18–25			
1650–1675	30–60	Cold water or brine	800–1000		75,000	40,000		3000 kg. 200		Note W—Used for propellors, fuselage, and other highly-stressed parts.

analysis. [e] O indicates "soft temper." W indicates "as quenched temper." T indicates "heat treated temper."

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[6] The so-called "quality factor" is obtained sometimes by multiplying the ultimate strength by the elongation, and sometimes by multiplying the ultimate strength by the reduction of area.

Table III—Ternary and Quarternary Alloy U. S. Army Aircraft-Structural Steels Analyses, Properties, Heat Treatment and Uses

U. S. Army Air Corps Spec.	Carbon	Analysis		Notes	SAE No.	Uses	Notes	Heat Treatment Quenched in Water (W) or Oil (O) at ° F.	Drawn at ° F.	Ultimate Strength, Lb./Sq. In.	Physical Properties (Minima) Yield Point, Lb./Sq. In.	Elong. % in 2"	Reduction of Area %	Brinell
		Ni	Cr											
57-107-3	0.35–0.45	1.00–1.50	0.45–0.75	a	3140[aa]	Connecting rods Structural Crank shafts	Z	1475–1525 O	800	180,000	150,000	13	45	343
									1000	135,000	115,000	17.5	57	277
									1200	110,000	85,000	21	62	226
57-107-4	0.35–0.45	1.50–2.00	0.90–1.25	a	3240[aa]	Connecting rods Structural Crank shafts	Z	1475–1525 O	800	200,000	175,000	12	52	390
									1000	155,000	130,000	15	56	320
									1200	115,000	100,000	20	63	230
57-107-6	0.45–0.55	1.50–2.00	0.90–1.25	a	3250[aa]	Connecting rods Structural Crank shafts	Z	1425–1475 O	400	260,000	150,000	8	38	540
									600	240,000	175,000	10	42	510
									800	230,000	190,000	12	46	460
									1000	175,000	150,000	14	50	380
									1200	130,000	105,000	18	57	260
57-107-7	0.30–0.40	2.75–3.25	0.60–0.95	a ±	3435[aa]	Structural	Z	1450–1500 O	600	225,000	130,000	10	40	440
									800	195,000	150,000	12	50	385
									1000	160,000	125,000	15	55	330
									1200	125,000	95,000	20	65	250
57-136-7	0.25–0.35	V 0.15–0.25	0.80–1.10	b	6130	Fittings and misc.	Z	1600–1650 O	400	220,000	110,000	10		
									600	200,000	125,000	10		
									800	175,000	150,000	11		
									1000	135,000	110,000	12		
									1200	115,000	90,000	15		
57-107-2	0.30–0.40	0.15–0.25	0.80–1.10	b	6135	Connecting rods Structural Crank shafts	Z	1575–1625 O	400	250,000	130,000	12.5	43	460
									600	230,000	175,000	12.5	45	420
									800	200,000	175,000	12	48	400
									1000	150,000	115,000	15	50	350
									1200	120,000	95,000	20	55	240
57-107-5	0.45–0.55	0.15–0.25	0.80–1.10	b	6150	Structural	Z	1525–1575 O						
57-107-11	0.90–1.05	0.15–0.25	0.80–1.10	c	6195	Ball races and parts requiring maximum hardness and high bearing loads	Z	1425–1475 O	350					
57-180-2	0.25–0.35	Mo 0.15–0.25	0.80–1.10	d	X4130	Structural	Z	1600–1650 W	400	230,000	110,000	5		
							Y			125,000	100,000	15		
10076	0.25–0.30	0.15–0.25	0.80–1.10	d ±	X4130	Structural	Z	1600–1650 W	600	205,000	125,000	6		
									800	180,000	150,000	8		
									1000	145,000	115,000	12		
									1200	115,000	90,000	20		
57-107-19	0.25–0.30	0.15–0.25	0.50–0.80	d ±	4130	Structural	Z	1600–1650 W						
	0.25–0.30	0.25–0.35	0.80–1.10			Structural								
	0.45–0.55	V 0.15–0.20	1.00–1.20	Mn 0.70–0.90		Chrome-Vanadium Spring Steel	W	1550–1575 O	850–1050	190,000 and up	175,000 and up	11 and less	30 and less	363–444
	0.50–0.60	Si 1.80–2.20	0	0.60–0.90		Silico-Manganese Spring Steel	W	1575–1600 O	850–1050	195,000–250,000	175,000–230,000	8–12	28–40	363–444

a Mn = 0.30–0.60, P & S not over 0.040 ±, Si 0.15–0.35.
b Mn = 0.50–0.80, P & S not over 0.040 ±, Si 0.15–0.35.
c Mn = 0.20–0.45, P & S not over 0.030, Si 0.15–0.35.
d Mn = 0.40–0.60, P not over 0.040, S not over 0.045, Si 0.15–0.35.

[aa] OH, crucible or electric.
Z Normalized, annealed, then quenched.
Y U. S. Army Air Corps Spec. 57-136-8-allow mfg. to decide on this heat treatment.
W Annealed at 1600–1625° F.

Table IV—Binary Alloy Steels and Monel Metal—Analyses, Properties, Heat Treatment and Uses

No.	Analysis C	Analysis Ni	Analysis Cr	Notes	SAE No.	Uses[aa]	Notes	Heat Treatment Quenched in Water (W) or Oil (O) at ° F.	Drawn at ° F.	Ultimate Strength, Lb./Sq. In.	Physical Properties (Minima) Yield Point Lb./Sq. In.	Elong., % in 2"	Reduction of Area, %	Brinell
A	0.25–0.35	3.25–3.75		*a*	2330	Connecting rods	W	1475–1525O	600	220,000	180,000	11	40	460
						Structural[aa]			800	180,000	150,000	12	50	390
						Bolts and nuts			1000	125,000	100,000	15	55	270
						Crank shafts			1200	95,000	75,000	20	60	225
B	0.15–0.25	3.25–3.75		*a*	2320	For carburizing[aa]	X	1500–1550O Then 1350–1400O	350–400	Of core 80,0000				
C	0.17 max.	4.50–5.25		*b*	2512	For carburizing[aa]	Y	1425–1475O Then 1350–1400O	300–350	Of core 120,000				
D	0.30–0.40		11.5–15.00	*c*	51235	Stainless[a] steel valves		1800–1850O	800	240,000	175,000	4	10	475
									900	230,000	170,000	5	12	460
									1000	220,000	160,000	7	15	440
									1050	200,000	150,000	10	25	400
									1100	190,000	140,000	12	30	380
									1150	170,000	125,000	15	35	330
									1200	140,000	100,000	20	40	280
10069[aaa]	0.90–1.00		3.40–3.60	*d*	x5395		Z	1500–1560O						
Manganese steel	1.00–1.15			Mn = 13%		Skid shoes		1830O F. W	Not drawn	150,000	70,000	50	50	
Monel Metal	Cu = 28	67	0	*e*		Fuel tanks—Pipe lines	Note V	Properties at room temperature		65,000–140,000	25,000–130,000	20–50	30–65	
								Properties at room 600° F.		82,000				
								Properties at room 800° F.		78,000				
								Properties at room 1000° F.		60,000				

a Mn 0.50–0.80, P not over 0.040, S not over 0.050, Si 0.15 to 0.35.
b Mn 0.30–0.60, P not over 0.040, S not over 0.045, Si 0.15–0.35.
c Mn 0.50 max., P not over 0.035, S not over 0.035, Si not over 0.50.
d Mn 0.25–0.35, P not over 0.030, S not over 0.030, Si 0.20–0.30.
e All other ingredients = 5%, chiefly iron.

W Normalized, annealed, quenched and drawn.
X Carburize at 1600–1650° F.—Cool in air.
Y Carburize at 1600–1650° F.—Cool in box to 100–1100° F.
Z Annealed, then hardened.
[aa] OH, crucible, or electric steel.

V Monel metal does not require heat treatment. It has a rather low strength-weight factor, but excellently resists corrosion.
A 98-10025[aaa]
B 57-107-12[aaa] Carburizing parts subjected to both high stresses and wear, such as wrist pins and pinions.
C 98-10025[aaa] and 57-107-18.[aaa] Carburizing parts for very high stresses, toughness and fatigue resistance—suitable for transmission gears, pinions, etc.
D 98-10025[aaa] and 57-107-13.[aaa] Stainless and corrosion-resisting steel.
[aaa] U. S. Army Air Corps Specification No.

Table V—Carbon Steels—Analyses, Properties, Heat Treatments, Uses

All These Steels Must Be Open Hearth, Crucible or Electric Process Made

No.	Analysis, % C	Si	Mn	P Not Over	S Not Over	SAE No.	Aircraft steels for	Heat Treatment Quenched in Water at	Drawing Temperature	Properties after Heat Treatment (Minima) Ultimate Strength Lb./Sq. In.	Yield Point, Lb./Sq. In.	Elong., % in 2"	Reduction of Area	Brinell Hardness
1	0.05–0.15		0.30–0.60	0.045	0.050	1010	Deep drawing	Annealed, preferably in box		38,000 to 40,000	20,000 to 24,000	35		Note A
2	0.15–0.25	0.15–0.35	0.30–0.60	0.045	0.050	1020	Carburizing steel	1400–1425° F.	350–400° F.	of core 60,000				
3	0.20–0.30		0.50–0.80	0.045	0.050	1025	Fittings and misc. bolts and nuts	Cold rolled and annealed		55,000	36,000	22		Note B
4	0.30–0.40	0.15–0.35	0.50–0.80	0.045	0.050	1035	Structural steel	1525–1575° F.	1000° F.	103,000	70,000	25	63%	200
									1100° F.	100,000	65,000	30	66%	195
									1200° F.	95,000	60,000	32	68%	180
5	0.40–0.50	0.15–0.35	0.50–0.80	0.045	0.050	1045	Cylinders, etc.	1475–1525° F.	1000° F.	115,000	80,000	20	55%	230
									1100° F.	110,000	75,000	23	58%	215
									1200° F.	100,000	70,000	25	60%	200
6	0.90–1.05	0.15–0.35	0.25–0.50	0.040	0.050	1095	Springs	1400–1450° F.	650° F.					

Note A—Must bend cold on themselves without cracking.

Note B—180° cold bend around dia. = thickness of spec.

Steel No. 1	Suitable for severe cold forming and deep cupping. U. S. Army Spec. 57-136-4.
Steel No. 2	**Carburizing steel.** Carburizes at 1650–1700° F. Cool in air. U. S. Army Spec. 98-10025 and 57-107-9.
Steel No. 3	**For fittings and miscellaneous parts.** Not suitable for deep forming or cupping. U. S. Army Spec. 57-136-3.
Steel No. 4	**Structural steel for aircraft.** U. S. Army Spec. 98-10025 and 57-107-20.
Steel No. 5	**Cylinders, flanges, hubs, etc.** U. S. Army Spec. 98-10025 and 57-107-15.
Steel No. 6	**Spring tempered strip steel.** U. S. Army Spec. 57-136-2.

cold drawn to an ultimate strength of 230,000 to 400,000 lb. per sq. in., depending inversely on the size. (The stronger wire would have a diameter of about 0.010 in.) The elongation in 2 in. would be from 8% down to 2% or less, in inverse order to the strength.

Future Possibilties in Aircraft Structural Alloys.—At about 90c per lb. the price of magnesium has militated against its use for aircraft structural parts. Magnesium alloys may have high strength-weight factors, but the yield points and moduli of elasticity are not favorable. It requires some investigator with powers equal to the inventor of duralumin to discover some combination which will make the alloys attractive at the cost asked, and discover a heat treatment which will overcome the present disadvantages. Magnesium alloys are available and have been used, but not commonly. Some analyses of commercial types are given in Table VI. The physical properties of these alloys vary, but are included in the figures given in Table VII.

A metal offering greater promise than magnesium is beryllium, and a great deal of work is now being carried on by several companies and individual investigators on alloys of this metal. It is found in sufficient abundance in the crust of the earth, but is costly to extract and recent quoted prices are in the neighborhood of $200 per lb., but it is said that it could be sold as low as $50 per lb. if used in large quantities. If alloys high in aluminum and low in beryllium were strong, a very high price would be no *insuperable* bar, but, unfortunately, the strong alloys are those with high beryllium. Beryllium has a high yield point and high melting point, thus avoiding the two chief objections to magnesium for structural parts as well as engine parts.

Table VI—Chemical Analyses of Some Common Aluminum-Magnesium Alloys Used in Aircraft[a]

		Chemical Composition—%						
Name	Use	Al	Mn	Zn	Si	Cu	Cd	Mg
AM4.4	Forging Extrusion Rolling	4.0	0.4	...	0.15	...	...	Diff.
AM7.4	Heat-treated castings	7.0	0.4	...	0.15	...	...	Diff.
Dow metal F	Castings Forgings	4.0	0.3	...	..	...	...	Diff.
Dow metal E	Castings Forgings	6.0	0.25	...	..	...	...	Diff.
Dow metal D	Castings	8.5	0.15	0.5	..	2.0	1.0	Diff.
Dow metal T	Castings Forgings	2.0	0.20	...	..	4.0	2.0	Diff.
Electron AFZ	Castings	4.0	0.35	3.0	0.3	0.3	...	Diff.
Electron AZG	Castings	6.0	0.35	3.0	0.3	0.3	...	Diff.
Electron VI	Die forgings	10.0	0.35	0.6	0.3	0.3	...	Diff.
Electron AZ31	Forgings	3.0	0.35	1.0	0.3	0.3	...	Diff.
Electron AZM	Sheet	6.3	0.35	1.0	0.2	...	...	Diff.
Electron AS82	Forgings	8.0	0.35	0.5	2.0	0.3	...	Diff.

[a] W. G. Harvey private communication, November 8, 1929.

Metals Used for Propulsion Parts in General

The 200-HP Wright "Whirlwind" engine of the radial, air-cooled type with nine cylinders which carried Lindbergh and 5000 lb. additional across the Atlantic at an average speed of about 100 miles per hour had a total weight of 508 lb. This means that the material must have a high strength-weight factor and also a great resistance to fatigue. Some parts, like valves and spark plugs, for instance, must resist heat for hours without failure. Light-weight alloys must be used for all parts not having great stress or fatigue to withstand (for fatigue resistance means high tensile strength), such as: crankcase[7] and similar coverings, cylinder heads,[7] pistons,[7] tubes, gasoline tank[7] and pipes,[7] etc. It can, therefore, be appreciated that aluminum alloys will form about 60% of the weight of water-cooled and 50% of the weight of air-cooled engines. The importance of fatigue will be realized from the recent report of a British investigating board of a disaster in which a passenger plane failed and fell into the English Channel, with loss of life. The cause was the failure of one of the engines through fatigue.

Table VII—Aluminum-Magnesium Alloys for Aircraft Production

Reference	Chemical Analysis %			Name of Alloy	Treatment or How Produced	Specific Gravity	Tensile Strength Lb./Sq. In.	Yield Point[a], Lb./Sq. In.	Physical Properties							
	Mg	Al	Mn						Elongation, % in 2″	Reduction of Area, %	Young's Modulus	Compressive Strength, Lb./Sq. In.	Impact (Dow), Ft. Lbs.	Endurance Limit[b], Lb./Sq. In.	Hardness Brinell	Hardness Scleroscope
W. G. Harvey, *Transactions American Electrochemical Society*, Sept. 23, 1929.					Sand castings	1.80	26,000–38,000	8,000–11,000	8–15	9–16	6,600,000	40,000–50,000	3.3–6.1	8,500–10,000	44–58	25–31
	92.6	7.0	0.4	No. AM 7.4	As cast	1.785	25,000	8,500	6	7	......	....	....	8,500	50	31
	92.6	7.0	0.4	No. AM 7.4	Cast and heat treated	1.785	33,000	9,500	10	12	......	....	....	10,000	51	31
					Extruded	1.80	42,000–45,000	22,000–26,000	11–16	13–20	6,600,000	60,000	....	....	56–62	29–37
					Cold rolled	1.77	40,000–45,000	20,000–27,000	5–10	...	6,500,000	....	....	....	60–64	37–39
					Rolled and annealed	1.77	37,000–38,000	20,000–22,000	18–24	...	6,500,000	....	....	....	51–53	31–33
					Hot rolled plate	1.77	35,000–36,000	15,000–20,000	10–14	10–15	6,500,000	....	....	....	50–55	31–36
					Light forgings	1.78	39,000–42,000	22,000–24,000	6–15	8–20	6,500,000	43,000–55,000	11.2–12.5	....	50–60	31–37
					Heavy forgings	1.78	35,000–37,000	20,000–24,000	8–14	10–20	6,500,000	40,000–52,000	11.2–12.5	....	50–55	31–36
	Commercially pure			Magnesium propeller blades	Forged	1.76 ±	34,000	22,000	6	...	......	....	....	....	...	...

[a] Considered as the load at 0.1% elongation.

[b] Rotating beam 500,000,000 cycles.

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[7] See Table II.

Table VIII—Ternary Alloy Aircraft Steels

U. S. Army Air Corps Spec. No.	C	Chemical Anaylsis Cr	W	Notes	SAE No.	Uses	Notes	Heat Treatment Quenched in Water (W) or (Oil O) at ° F.	Drawn at ° F.	Ultimate Strength Lb./Sq.In.
10068	0.60–0.70	0.40–0.60	5–6	*a*	X7565		X	1550–1600 O	.....	....
57-107-23	1.00–1.50	10–13	Mo 0.60–0.90	*c* also Co 3.00–3.50	....	Exhaust valves	..	......	.....	....
57-107-22	Not over 0.17	1.25–1.75	Ni 3.25–3.75	*d*	3312	For carburizing	Y	1425–1475 O then 1350–1400 O	300–350	100,000
57-107-10	0.10–0.20	0.80–1.10	V 0.15–0.18	*d*	6115	For carburizing for both high stresses and wear such as wrist pins and pinions	Z	1550–1600 O then 1450–1500W	350–400	90,000

a Mn 0.45–0.60, P not over 0.030, S not over 0.030, Si 0.20–0.30.
c Mn not over 0.50, P not over 0.030, S not over 0.030, Si 0.20–0.30.
d Mn 0.30–0.60, P not over 0.040, S not over 0.040, Si 0.15–0.35.

X Annealed and then hardened.
Y Carburize at 1600–1650° F.
Z Carburize at 1625–1675° F.

Pins, gear teeth, etc. must resist surface wear and yet be tough and withstand severe stresses on occasion. This means case carburizing and heat treatment, and often case carburizing of very special material (for which see Tables VIII, V, IV and III). Each part of the propulsion mechanism is a special study in itself, but we have space here to discuss only a few representative members, such as: cylinders, connecting rods, crank shafts and high-heat resisting parts.

Metals Used for Engine Cylinders.—It has been estimated that the gases inside an aircraft cylinder will reach a temperature of 4400° F. The inside of the cylinders must, therefore, withstand heat. The service is naturally not so severe in the case of water-cooled engines as in that of air-cooled cylinders, and it was believed for some time that the water-cooled cylinder gave better efficiency. But there are such obvious advantages in air-cooled engines in aircraft, that this type has been growing in popularity. The radial type is now always used. Both water- and air-cooled cylinders have been made of special cast irons, because of easier machining, but the weight is against this material, and steel is standard in most designs. The water jackets are made of very thin sheet steel or aluminum or dural, in some cases. Air-cooled cylinders are machined for making the fins, because of less weight than castings. It is important that the inside of the cylinder be hard to resist the wear of the piston rings. For this reason, dural has not been successful, although a dural cylinder with steel liner has been tried experimentally, with some apparent success. The great loss of strength of dural with even incipient red heat (1000° F.) is shown in Fig. 1, these graphs representing alloys whose analyses are given in Table IX. This loss of strength is a

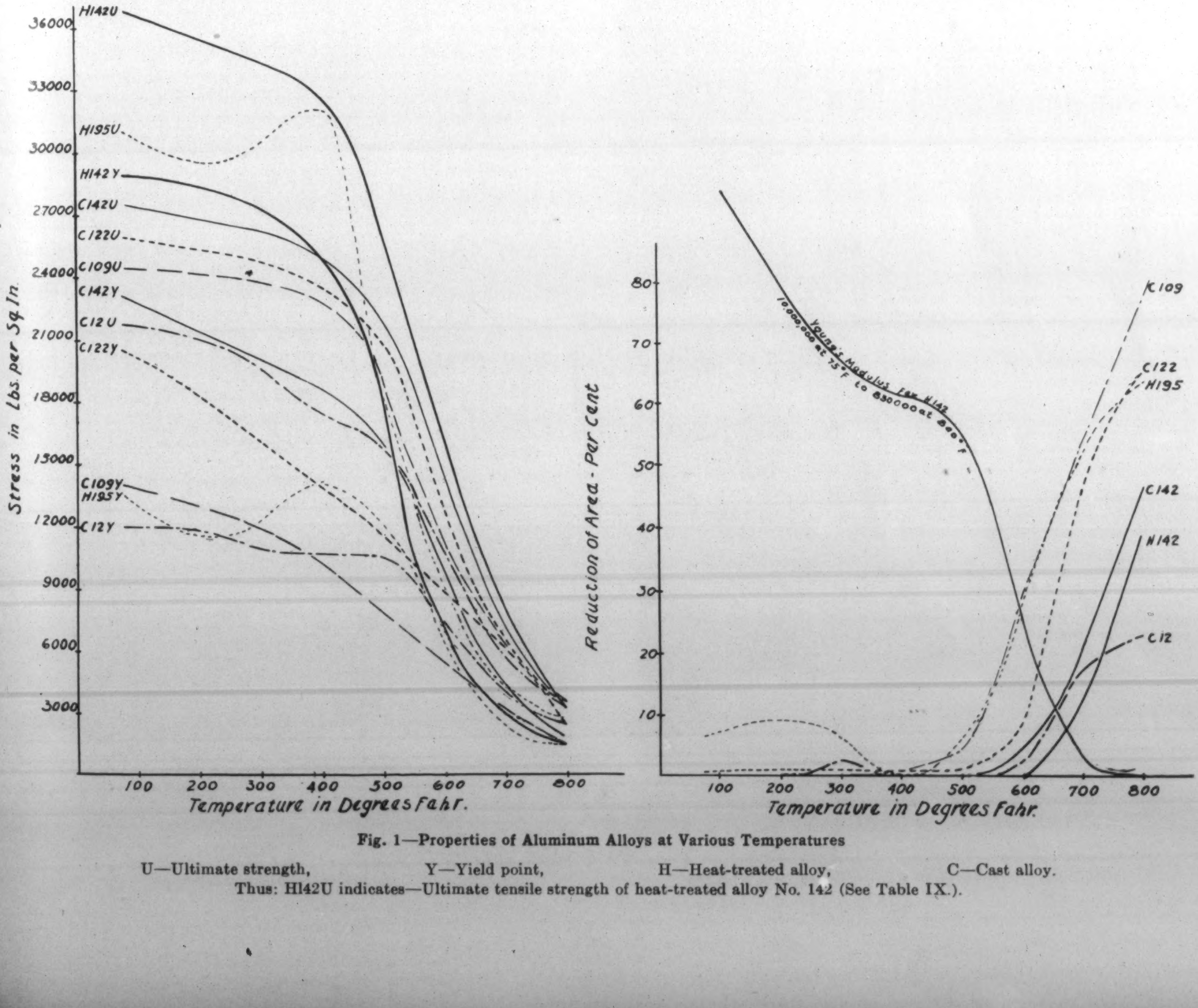

Fig. 1—Properties of Aluminum Alloys at Various Temperatures

U—Ultimate strength, Y—Yield point, H—Heat-treated alloy, C—Cast alloy.
Thus: H142U indicates—Ultimate tensile strength of heat-treated alloy No. 142 (See Table IX.).

detriment in cylinders, although not in itself an absolute bar. Steel cylinders nitrided on the inside have given most encouraging results in Europe, and it is expected that this development will be followed up vigorously. It is said that magnesium pistons may be used in the nitrided cylinder with advantage. Analyses and properties of an approved type of cylinder steel is shown in Table V.

Table IX[a]—Nominal Chemical Composition of Aluminum Casting Alloys Commonly Used in Aircraft Engines

(See Table II and Fig. 1 for Physical Properties)

Alloy	Copper (Cu) %	Nickel (Ni) %	Magnesium (Mg) %	Iron (Fe) %	Silicon (Si) %	Aluminum (Al) %
109	12.0	0.0	0.0	...	..	88.0
12	8.0	0.0	0.0	...	..	82.0
122	10.0	0.0	0.25	1.2	..	88.6
142	4.0	2.0	1.5	...	..	92.5
195	4.4	0.0	0.0	...	..	95.6

NOTE: Where no figures are given, iron and silicon exist as impurities only.

[a] From: G. D. Welty, *S. A. E. Journal*, November 1929, page 470.

Connecting Rods and Crank Shafts.—For connecting rods we require resistance to fatigue (alternating stresses), and standard nickel steel (S. A. E. 2330, Table IV) is as good material as can be used. But, as said previously, nickel-chromium steel (Table III) is cheaper, laminates less and is almost as good. Chrome-vanadium steel (Table III) is also an approved type, but is more valuable in crank shafts, because the hardness it has on the case-carburized parts (which we especially want with a hard surface) is an advantage, whereas hardness is often accompanied with lower toughness, which causes some makers to prefer the chrome-nickel steel both for connecting rods and crank shafts. It is the vanadium which gives the extra hardness to the high-carbon surfaces, and also reduces the toughness somewhat. Each of these steels has its advocates, not only for connecting rods and crank shafts, but also for gears in the transmission. Naturally, each requires judgment in the heat treatment applied, as shown in Table III, and a study of this Table will bring out the relative merits of the materials. It is pertinent to remark at this point that fatigue resistance means high tensile strength and also clean metal—one that is relatively free from specks, oxides, inclusions, etc. and this means steel made by the crucible process, or else by the most careful and approved practice in the electric furnace.

Heat Resisting Parts

This paper is already too long to permit of a discussion of the relative merits of heat-resisting metals, but the facts are set forth briefly but comprehensively in Table X. The parts of spark plugs which do not have to withstand extreme temperatures can be made of stainless steel (see Table IV), but the electrodes must be of nichrome (Table IX) or else high tungsten steel. Inlet valves have to withstand a temperature of about 1100° F., and exhaust valves, 1600° F. They have to withstand not only the high heat, but also the pounding which tends to distort them so they will not seat properly. This explains the conflicting merits of tungsten and chromium steels discussed in the notes of Table X. High tungsten steel will scale at a red heat, and the neck of the valve will unfortunately reach this temperature in time. However, both types of steel are helped if the valve is "salt filled." That is, the valve stem is hollow and contains a small amount of a mixture of potassium and sodium carbonates, in eutectic proportions. This salt volatilizes at the hottest place and condenses again in cooler parts, thus cooling the worst portion. In his historic flight, Lindbergh used salt filled tungsten valves.

Table X—Some Common Heat-Resisting Alloys—Analyses

No.	Name and Notes	Fe, %	Chemical Analysis W, %	Cr, %	Ni, %	Si, %	Notes	Heat Treated or Not	Heat Resisting Properties, Etc.
1	High tungsten steel	80–85	Above 14	Sometimes See No. 5	0		Note A	Yes	Strongest substance known at 1600° F. but scales more than No. 2 or No. 3
2	High chrome steel	64–81	0	18–35	0			Yes	Not as good for valves as No. 3
3	High chrome-nickel steel	70–75 ±	0	17–20	8–10		Note B	Yes	Very effective for exhaust valves—not as strong as No. 1 at high temperatures
4	Silchrome	79–89	0	8–17		1.50–3.00	Note C	Yes	Effective for exhaust valves—Less costly than Nos. 1, 2, 3, 5
5	High tungsten steel	About 77–81	15–18	3–4		0.15–0.35	Note D	Yes	U. S. Army Air Corps Spec. 57-107-1 for exhaust valves, better than No. 1, Note A
6	Low tungsten steel	About 96	1.50–2.00	0.50–1.00		0.15–0.35	Note E	Yes	U. S. Army Air Corps Spec. 57-107-21 for valves
7	Nichrome	10	0	22	66		Mn = 2%	No	Does not scale at high temperatures. Not as strong as Nos. 1–6
8	Stellite	Sometimes	20–45	15 ±	Sometimes		Co = 40–65%	No	Not as strong as Nos. 1–6
9	Monel metal	Note H	0	Cu = 28%	67	0	Note H	No	T. S. = 60,000 lb./sq. in. at 1000° F. See also Table IV

Note A—The tungsten exhaust valves are partly cooled by being filled with a mixture of 45% by weight of sodium nitrate and 55% potassium nitrate. Lindbergh used such a valve in the historic flight of "We."

Note B—*Iron Age*, Oct. 3, 1929, page 888. This is an austenitic steel annealed by quenching from 1900–2100° F. The carbon is 0.07 to 0.15% as desired—Si under 0.75%—Mn under 0.50%—P and S under 0.025% at atmospheric temperature. T. S. = 85,000–95,000 lb./sq. in. Y. P. 30,000–40,000. El. 55–60% in 2". R. A. = 70–75%; Brinell = 130–140; Izod (V notch) = 100–120 ft. lb. It would be very desirable to have some manufacturer obtain data on physical properties at 1600° F.

(Note C) C 0.45–0.50. (Note D) C 0.50–0.70. (Note E) C 0.50–0.70. Note H 5%. Other metals, chiefly iron.

Aluminum and Its Alloys in Aircraft[1]

By T. W. Bossert[2]

In every form of transportation a significant transition has occurred with its development. In water transportation, for example, all ships and boats, large or small, were of wood construction before the days of the Civil War. To-day wooden ships are still sailing the seas, it is true, but they are relatively few and small, while ships constructed of metal transport the world's goods and form the world's navies. In rail transportation, cars were constructed with wood superstructures. In the past few years there has been a rapid change from wood to steel construction, and just lately railway car manufacturers are substituting aluminum for steel because of the large saving in weight realized thereby.

As in water and rail transportation, a transition has been and is taking place in the aircraft industry. In the early pioneering days of the heavier-than-air craft, the entire structure of the plane consisted of wood and fabric covering. To-day a large majority of planes have a metal fuselage, an increasing number of manufacturers are abandoning wood for metal wing construction, and the same trend towards the use of metal is evident in covering material for fuselage and wing.

Rigid, lighter-than-air craft have always had metal frame construction, with rubber-coated fabric containers for the gas. Even in this field pioneer efforts are being made toward employing very thin metal sheets, riveted together to form a gas-tight metal envelope, which not only serves as the gas holder but also forms part of the structure of the ship. Two rigid airships of this type are being built in this country at the present time.

There are many reasons for the change pictured above. Important among these are the points relating to material supply, dimensions and form, as well as flexibility of application, all of which favor metal as compared with wood, but in the present stage of the aircraft industry these are not as important as are the factors safety, dependability, uniformity of material, durability and physical properties which are also in favor of metal. This paper is concerned only with transportation in the air, and the last-named factors are therefore the important ones. In the aircraft industry, therefore, metal is being regarded with constantly increasing favor as a material for fuselage and wing construction and covering. Its place in the construction of power units and their accessories is obvious.

The two metals which find particular application in aircraft structures are steel and aluminum. Were it not for the science of electrochemistry, the widespread use of aluminum, with its many advantages, would probably be unknown, for it is by an electrochemical process that this metal is produced. The light weight of aluminum, roughly one-third that of steel, and the development of high strength alloys, similarly light but with the strength of structural steel, together bring it into favor in this field.

These high strength alloys are given their superior properties by heat treatment. They are of two types, namely (1) those which, after heat treatment, must be reheated to about 150° C. for a period of time in order to develop their maximum properties, and (2) those which age or harden spontaneously at room temperature after heat-treatment. Alloys of the first group, that is, those which must be reheated at 150° C. after heat-treatment, are the aluminum-copper-manganese-silicon alloy (25ST), and the aluminum-magnesium-silicon alloy (51ST).

The alloy 25ST, after the above ageing treatment, has a tensile strength similar to that of mild steel, namely, from 55,000 to 60,000 lb./in.^{2} (4218 kg./cm.^{2}), a yield point of 30,000 to 35,000 lb./in.^{2} (2109 kg. to 2460 kg./cm.^{2}) and an elongation of about 18%. It is widely used for the production of forgings for aircraft. One of the best examples of aluminum alloy forgings is the 25S propeller blade. Its virtues are many when compared with the wooden type. The metal propeller is extremely durable, it is not affected by changes in weather conditions, it is not scored or cut by deep grass, which is an extremely important fact in cross country air travel, and in a crash it will bend but not break. A bent propeller can also be straightened and used again with assurance that its life has not been appreciably shortened.

The alloy 51ST does not attain the strength found in 25ST, but because of its excellent workability it finds many applications where the highest strength is not the important requirement. The crankcase on a well-known radial engine is a 51ST forging.

The best known of the strong aluminum alloys is the one popularly termed "Duralumin" or "Dural" and termed by one producer, 17ST; it belongs to the second class mentioned above. This alloy contains, besides iron and silicon, copper and magnesium as principal constituents as well as a small amount of manganese. The alloy is relatively soft and workable immediately after heat treatment, but hardens or ages

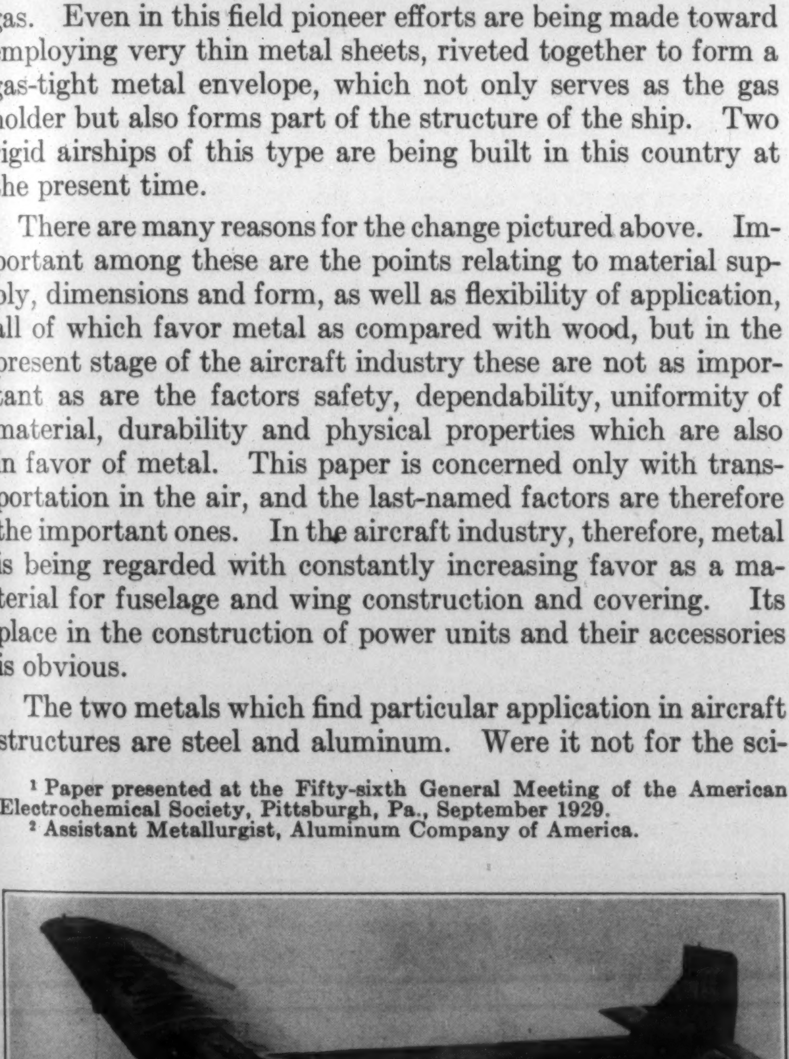

Fig. 1—Ford Tri-Motor Plane with 17ST Structure and Corrugated Alclad 17ST Covering

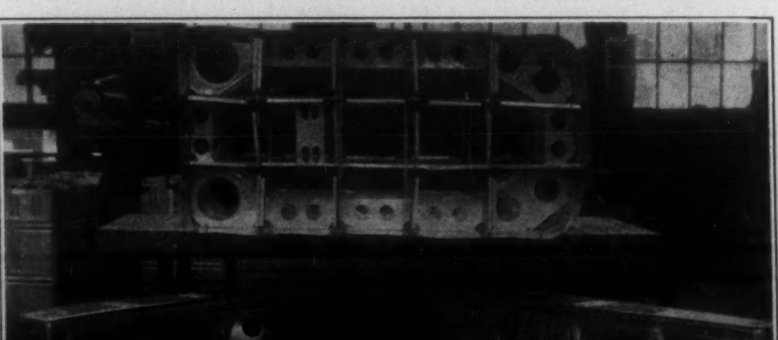

Fig. 2—Showing Internal Structure of Large Welded Pure Aluminum Tank and Two Welded Pure Aluminum Wing Tanks

during the four days following quenching, so that it attains about the same tensile properties as does 25ST.

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[1] Paper presented at the Fifty-sixth General Meeting of the American Electrochemical Society, Pittsburgh, Pa., September 1929.

[2] Assistant Metallurgist, Aluminum Company of America.

This alloy is the one used the most for aircraft structures. In the fully aged condition its workability is superior to that of 25ST. Furthermore, since the workability of the alloy immediately after heating and quenching is considerably above that of the aged material, many manufacturers take advantage of this fact in difficult forming operations.

The question naturally arises as to why aluminum alloys are employed when there are available very high strength alloy steels which would compare favorably with these alloys on the weight-strength basis. Such steels are used to a great extent in fuselage construction, but there are many cases where aluminum has been employed with a saving in weight. The answer lies in the fact that section thicknesses employed in aircraft are very light, because of the necessity for weight saving, and that steel sections would have to be so thin, in order to compete with aluminum alloys on the weight-strength basis, that the resulting structure, although being as strong as that made of aluminum, might, however, be flimsy. That is, it would not resist permanent deformation by suddenly applied local stresses.

A survey of the aircraft industry shows, first of all, that military ships are predominantly of metal construction, and that the proportion of aluminum used to other materials is continually increasing. In one large bombing plane the wing structure, control surfaces and fuselage, except for the engine mounting, are made of aluminum alloy tubing and sections built up of aluminum alloy sheet. The covering for fuselage and wing is fabric. All control members are aluminum alloy castings or forgings. A large number of other planes are constructed with aluminum alloy fuselage or wing structure and with the control surfaces covered with aluminum alloy sheet. Gasoline and oil tanks are made from unalloyed aluminum, where strength is not the primary requirement.

In the commercial field, mention is made of two types of large planes, one a 14-passenger tri-motor type, which are constructed almost entirely of aluminum alloy. Not only are the fuselage and wing structure aluminum alloy, but in addition the material covering these structures is corrugated sheet of Alclad 17ST, a material recently developed in the laboratories of the Aluminum Company of America. In one of the types mentioned above, the entire structure, except for tubing members, is made of Alclad 17ST. The outer surface of the Alclad covering is not painted or protected in any manner, because of the remarkable resistance of the new Alclad alloy sheet to atmospheric attack.

Alclad metal is of particular interest because of its make-up, and also because of its corrosion resisting characteristics. It is a composite sheet whose strong alloy core is covered on either side with a sheath of very pure aluminum. The coating is completely alloyed with the core at the surface of contact as evidenced by the fact that the constituents of the strong alloy core actually diffuse into the high purity coating. Were it not for the electrolytic refining process[3] by which very pure aluminum is produced, the availability of the high purity metal for coating material would be greatly limited.

Alclad metal is of further interest because its most remarkable characteristic is electrochemical in nature. A coating of very pure aluminum is considerably more resistant to corrosion than are the strong aluminum alloys, and for this reason the alloy core would be protected by the pure aluminum coating, just as would be the case with a paint coating. In addition, however, exposed portions of the core are also protected, because the high purity aluminum is electro-negative to the alloy core. It has been found that exposed areas one inch (25 mm.) in diameter are effectively protected against corrosion in this manner.

In the field of castings, aluminum alloys are finding wide application. In this class also heat-treated castings are available. They have a strength considerably greater than that of most other aluminum casting alloys, and have ductility and shock resistance far superior to such alloys as No. 12 (8% copper, 92% aluminum), No. 43 (5% silicon, 95% aluminum), etc. Castings of these heat-treated alloys are employed to a large extent in aircraft engines; in fact, were it not for the aluminum alloys the very low weight horsepower ratio obtainable in aircraft engines would not be possible.

The weight of aluminum used in aircraft engines amounts to 50–60% of the total engine weight, depending on the type of engine; that is, whether it is air- or water-cooled. In the water cooled engine the following parts are generally of aluminum alloy; cylinder block, cylinder heads, crankcase, oil pan, gear housings and pistons. In the air-cooled engine, of which the majority are the radial type, the crankcase cylinder heads, rocker boxes, rocker box covers, nose piece, super charger and pistons are aluminum alloy.

The aluminum alloy piston deserves special mention, because of its universal use in aircraft engines. The lightness and high heat conductivity of the aluminum alloy piston are important factors in reducing vibration and increasing the efficiency in the internal combustion engine.

In lighter-than-air craft the accepted material for rigid airship construction is the Duralumin type wrought alloy. Among the well-known ships having this construction are the Los Angeles, Graf Zeppelin and the two new giant airships being built for the government by the Goodyear Zeppelin Corporation. A small rigid airship now nearing completion in Detroit has a structure of wrought strong alloy, and is covered with thin sheets of Alclad metal, approximately 0.010 in. (0.25 mm.) thick.

These sheets are riveted together, the joints are sealed, and the envelope thus formed serves as the container for the helium gas. None of the conventional gas bags found in other rigid dirigibles are to be employed in this new development. The function of the metal sheathing is twofold. It serves not only as the gas container, but also forms part of the structure of the ship, thus taking some of the stresses imposed in flight, which would normally have to be absorbed by the internal beams, etc.

Notices have appeared in the papers recently regarding the successful trial flight of a giant airplane built at Friedrichshafen, Germany. This plane is equipped with twelve 500-horsepower motors, and is designed to carry approximately 110 persons. This ship is constructed almost entirely of aluminum alloy, and was built by one of the two pioneer builders of all-metal aircraft.

One additional aluminum product, namely aluminum bronze powder, has such wide application where protection against sunlight, moisture and salt water plays a part that its importance in the aircraft industry cannot easily be overestimated. Aluminum pigmented paints are widely used as protective coatings for metal in those cases where corrosion is to be avoided, especially where the structure is also exposed to sunlight. Aside from the practical reasons given above, aluminum pigmented paint owes much of its use in heavier-than-air craft to its pleasing color. In lighter-than-air craft the high reflectivity of the aluminum pigmented paint is of particular value for the covering of the ship.

A highly reflecting surface absorbs less radiant heat than does one with lower reflectivity. Consequently volume changes in the buoyant gas will be less in a balloon whose covering reflects a larger proportion of the sun's rays, and in this way conservation of the gas will result.

The development of new wrought and cast alloys with improved characteristics is constantly going forward, and it is safe to predict that the use of this relatively new metal, and its alloys in aircraft will rapidly increase with the passage of each year.

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[3] F. C. Frary, "The Electrolytic Refining of Aluminum," *Trans. Am. Electrochem. Soc.*, **47**, 275 (1925).

Recent Developments in the Metallurgy of Cast Iron

By Dr. Richard Moldenke[1]

A recent discovery in the metallurgy of cast iron which may be considered epochal, bids fair to restore this useful material of construction to very nearly the place it occupied before the serious encroachments of the steel casting. This discovery is the ability of cast iron melted under ordinary conditions of super-heating to retain minute particles of undissolved graphite in suspension, which particles—microscopically small—form nuclei for the subsequent growth to large crystals of graphite as the molten metal freezes.

If, however, such molten metal be given additional heat, so that end-temperatures between 2800 and 3000° F. be attained, these suspended graphite nuclei will all be dissolved. When cooling to the point of solidification, with no nuclei favoring the early formation of large graphite crystals, the metal will actually sub-cool somewhat below the ordinary point of solidification, and in setting, precipitate out the graphite in very fine form with resultant greatly increased strength and other good physical properties given to the castings.

The proof of the above statements may be readily had by melting cast iron of suitable composition in the crucible, and with constant rises in temperature successively pouring test blocks, one series into "chills" to get white iron, and another series into sand, to get gray iron structures. Observation of the white cast iron series under the microscope will show an abundance of graphite nuclei, say at 2400° F., with fewer progressively as the temperatures go up, all being gone at about 2850° F. Meanwhile, the corresponding sand-cast blocks will show the range from coarse graphite crystals to the very fine. Tensile test pieces cut from these gray cast iron blocks will show the more than doubling of the strength of the iron in similar course.

With the fundamental conception of gray cast iron as a steel matrix with interspersed crystals of graphite to weaken the structure, it will be readily seen that the breaking of the continuity of the steel matrix by the planes of comparatively weak graphite must be less serious for finely divided material of this kind than for the coarse. Hence, with about the same quantity of graphite thrown out—depending upon the composition and rate of cooling—the finer variety always goes with the higher strengths. Further, the composition of the steel matrix will be most important; for instance, whether the phosphorus content be 0.08 or 0.80.

While, on general principles, it is thus possible to greatly improve the quality of any variety of cast iron by melting the mixtures under conditions making for extreme degrees of super-heat, to get the best results, the composition aimed at must be seriously considered. Since it is necessary to have as few and as small planes of weakness in the steel matrix of cast iron as possible, and since it is also desirable to have the castings be readily machinable, the total carbon must be held as low as possible consistent with the nature of the material, and should consist of nearly all graphite and this in a very finely divided condition. Further, to insure a plentiful precipitation of graphite, the silicon must be held quite high. Again, manganese, always a factor for deoxidation, is best also held high. There remain the phosphorus and sulphur. The lower these are the better, for both phosphides and sulphides of iron are weak and affect the steel matrix of cast iron injuriously.

As an example for all around excellence, the following composition, which can be varied considerably to suit specially thin or thick sections of metal, will serve: Total carbon, 2.75; silicon, also 2.75; manganese, 1.00; phosphorus, 0.08; sulphur, 0.08. For those who are familiar with foundry melting practice, a glance at the composition in question will show that for a furnace heat very high grade pig irons rich in silicon must be used, and the carbon of these diluted with a sufficiency of steel scrap. Air furnace practice, unless with preheated blast, will not allow more than 35% steel in the mixture because of temperature conditions, and more than likely some ferroalloys will have to be added to the bath. For the cupola, however, the analysis in question means a practically all-steel heat, with ferrosilicon and ferromanganese charged with the steel. Since it is now possible to briquette the powdered ferroalloys with cement and thus protect them from oxidation until they actually melt in the proper cupola zone, the results are quite reliable.

Referring back again to the behavior of the graphite nuclei in cupola melting under increasing conditions of super-heat, the higher the temperature the more complete being their solution in the molten iron. The action here is very rapid, the drops descending through the fuel bed in short order. As the molten iron is not held long before pouring off into the molds, the opportunity for a proper solution of the graphite nuclei is limited. Hence, the necessity for extreme degrees of super-heat to accomplish this desirable result in the time available. With a furnace melt, the situation is a different one, and plenty of time being had for solvent action, this is effected satisfactorily under somewhat lower temperature conditions. Indeed, long before the presence of graphite nuclei in molten iron was recognized, it was possible to compare the fractures of furnace and cupola irons of the same composition and note the uniform distribution of the fine graphite in the first, as against the coarsely graphitic structure in the middle, shading to finer graphite at the edges, on the part of the other.

Another item in connection with high-test cast iron is of interest. The microstructure of the castings made is predominantly pearlitic. This is the most desirable structure for strength, machinability and wear, and much attention had been given the matter previously, literature being full of so-called pearlitic cast iron references. The ordinary way to obtain this structure in small and medium sectioned castings is to pour a very low silicon iron into highly-heated sand molds. The great retardation of the rate of cooling thus effected bring about a gray iron result from what would be a normally white iron, the silicon content being about 0.65, or that of the malleable casting before passing through the annealing process. The use of a definite silicon content in molten cast iron poured into sand molds heated up to a definite (almost red-hot) temperature constitutes the so-called "Lanz" pearlitic iron. It is a good material and the only disadvantage lies in the necessity of melting very low silicon irons in the first place, this requiring special care and ability. Further, when the sections of such a casting become quite heavy, the structure is not always pearlitic.

Another item of interest appears when the silicon is held lower than should be the case for high-test cast irons. Thus, if instead of aiming for 2.75 silicon, this figure is lowered to 1.75, the graphite formed as the metal sets, though fine, will be very much less in evidence, the fracture of the casting being mottled and turning toward whiteness. Such a casting, however, when exposed to an annealing process of nearly 1600° F. for about six hours, has the cementite present broken up into

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[1] Watchung, N. J.

ferrite, pearlite and temper carbon—exactly as in the malleable casting, and can be bent, twisted and upset cold just as such a casting. Here, then, is the means of producing malleable castings of up to 12-in. thickness—a thing impossible with ordinary malleable casting procedure.

The above is but an outline of the present-day knowledge of improving cast iron to a previously not dreamt of degree. If an alloy cast iron is made of this material, by the addition of nickel, molybdenum, tungsten, chromium and other metals—small quantities of these if absolutely free from graphite being added to the ladle of iron, and larger ones put into the cupola via the cement briquettes previously mentioned, a still stronger and better iron is obtained, the steel matrix becoming an alloy-steel one, and strengths up to 70,000 lbs./in.^{2} being not uncommon. There is still much controversy between the interested observers on the various phases of the phenomena presented, and as each one seems to have found it incumbent to patent his method, a confusion of interests has resulted, the likelihood being that foundrymen will ignore them all and quietly melt steel scrap in the cupola exactly as formerly, but on a more intensive scale and with a clear understanding regarding the effects of attaining exceptionally high degrees of super-heat. Foundrymen will do well to remember that this intensely hot iron must be allowed to cool in the ladle sufficiently before pouring off into sand molds, so that these are not cut to pieces. Further, that any addition of scrap gray iron to hasten the cooling will, by the introduction of graphite into the molten iron, spoil the very object of the high temperature attainment. Thus, he will have no difficulty in vastly improving his product. Furthermore, the higher fuel percentages required to do this intensive melting make for less oxidation troubles, and the soundness of the castings will be greatly enhanced. The means for a "come-back" of cast iron, are, therefore, at hand, and the avidity with which foundrymen are grasping their opportunity argues for a brighter era ahead of the gray iron foundry.

Structural Steel Welding

By Frank P. McKibben[1]

Present Status

That the art of welding structural steel by the electric arc is progressing rapidly is shown by the recent successful completion of over seventy-five bridges and buildings which have been wholly or partially welded. Included in these are the following illustrations: (*a*) A steam power plant 144 ft. in height for Hotel Chalfonte, Atlantic City, fabricated, erected and welded by the Bethlehem Steel Company; (*b*) a twelve story addition to Hotel Homestead, Hot Springs, Virginia, fabricated, erected and welded by the American Bridge Company; (*c*) a half-through plate girder railroad bridge, and a through truss railroad bridge, at plants of the Westinghouse Electric and Manufacturing Company; (*d*) a large factory building of the mill type and a heavy three story factory at plants of the General Electric Company; (*e*) plate girders each carrying 870,000 lbs. central load designed and built by the General Electric Company for use as parts of a thrust bearing in a power plant.

Welding and Building Codes

Many cities are now revising their building codes to permit welding, but even without a specific clause covering welding, many codes permit the process because they include a clause to the effect that if the Commissioner of Buildings is satisfied after proper investigation that a new material or the new use of an old material is safe, he may authorize its use.

The Uniform Building Code prepared by the Pacific Coast Building Officials Conference, containing a section permitting welding, has been adopted by over forty towns and cities, and the American Welding Society's Committee on Building Codes has drafted a code to cover gas and electric welding, which may well serve as a model for cities to follow.

Tests on Welded Joints

Tests on welds may be classified as determining:

1. Longitudinal shearing value of fillets.
2. Transverse shearing value of fillets, involving simultaneous tensile or compressive stresses on some planes within the fillets.
3. Tensile and compressive strengths of welds in butt joints.

Sufficient test data pertaining to strengths of welded joints are available to enable engineers to produce safe designs, but additional tests are desirable to complete a thorough study of this subject.

Tests are needed to throw more light on longitudinal shearing strength of fillets as influenced by length, size and number of layers, and while sufficient work has been done to know that these variables do influence the average strength of the fillets, the exact laws of variation have not been established.

Fillets in transverse shear should give greater strength than in longitudinal shear, because in a properly designed joint the former should have each linear inch of fillet subjected to the same stress; whereas in the latter some inches carry greater stresses than others just as the end rivets in a row carry greater stresses than does the center rivet.

Welded Plate Girder

Sufficient emphasis has not been laid upon the advantages of welding as compared with riveting in plate girder construction. In a welded girder consisting of a vertical web with one or more plates in each flange, four factors operate to reduce the weight of steel as compared with the weight of riveted girders performing identical functions. These are: Increase in the effective depth, hence, greater moment of inertia of cross section for a given weight of steel; general use of gross areas instead of net for tension flanges of welded girders because of the absence of holes; the use of flat bars for web stiffeners instead of angles, thus eliminating the ineffective angle leg against the web; the absence of loose fillers.

The savings in weight resulting from these factors are very considerable; for example, welded and riveted girders of 40 ft. spans carrying 4000 pounds per foot on each entire span and designed for the usual building unit stresses weigh 5467 pounds, 6455 pounds respectively, a saving of 988 pounds, or 15.2% of the riveted girder. With the use of automatic welding machines this large saving in weight should likewise result in a considerable cost reduction.

Qualification of Welders

Before being allowed to weld steel members in an important building, welders should be tested to show their ability to do the kind of work required. These qualification tests should be performed under the supervision of the engineer in charge of the structural steel, who should require the contractor for the steel to show that his welders are qualified to perform the work properly.

These tests should cover: welds in horizontal, vertical and overhead positions; fillets deposited along the offset edges of two plates which upon cooling and breaking apart should show good penetration into the base metals; freedom from gas pockets, slag inclusions and highly colored spots. If the welder's ability is still in question, he should weld some sample butt welds and some longitudinal shear welds which upon testing in tension should show satisfactory tensile and shearing values.

Inspection of Shop and Field Welding

A capable inspector can tell by visual inspection enough about a weld to classify it as good or poor, and inspection has progressed to the point where structural engineers familiar with the subject have ample confidence in welded joints. The inspectors should observe the ammeter to ascertain whether the welder is using the proper current values; should know the chemical composition of the welding wire; should observe by sound and sight whether the arc is short as it should be, or long as it should not be; whether the edges of fillets are sharp and feather-like, or rounded, the former indicating good penetration; whether the fillet and crater are free from gas holes as they should be; whether the crater is of proper depth below surface of the steel.

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Fifty Years of Physical Metallurgy*

By Herbert M. Boylston†

Early History. Up to about 1904 physical metallurgy or metallography, as it was usually then called, was still in its infancy. To be sure efforts had been made much earlier to study the physical properties of metals and especially those of steel. As early as 1665, Robert Hooke, in his *Micrographia*, described the appearance of the edge of a razor under a lens. Reamur, in 1722, and Widmanstättan, in 1808, had examined metals and minerals under the microscope and Reamur and later Breant in France in 1820 had interested themselves in the study of Damascus sword blades, while General Anossoff, engineer of mines and director of the Zlatoust Steel Works in Russia, also experimented over a long period (from 1831 until his death) with Damascus blades and with alloy steels. Anossoff's work was lost to view at first but later was taken up by Professor D. K. Tschernoff of the Imperial Academy of Artillery at St. Petersburg. The influence of his work reaches down to the present day. Rinmann of the University of Upsala, Sweden, as early as 1774 had written upon the characteristics of steel and the effect of carbon upon its composition and Vandermonde, Berthellot and Morge pointed out in 1786 that the distinguishing factor in steel was carbon.

It is said that Galileo invented the microscope as distinguished from a simple magnifying lens but it was not until 1863 that H. C. Sorby, then a student of mineralogy and geology at Sheffield, England, began a systematic research on the application of the microscope to the problems of metallography and to-day we hail Sorby as the founder of the science of metallography. Sorby's methods were first made public in a paper delivered before the Literary and Philosophical Society in Sheffield, England, "On a New Method of Illustrating the Structure of Various Kinds of Blister Steel." He soon followed this with his famous contribution to the Iron and Steel Institute of Great Britain, "On Microscopical Photographs of Various Kinds of Steel." Little attention was given to this early work, however, until Professor A. Martens at Charlottenburg, Germany, published his paper (about 1877), "On the Microscopic Investigation of Iron." About the same time Floris Osmond at the Le Creusot Works in France, with his colleague, Werth, begun to investigate the possibilities of microscopic examination as applied to steel. Sorby took up his work again and lectured on the subject at Firth College in Sheffield, in 1882, and in 1886, using for the first time a magnification of 650 X, made the momentous discovery of the constituent now called Pearlite.

J. C. Bayles, editor of *Iron Age*, in 1869–1889 began to urge the adoption of microscopic tests to support physical and chemical analysis.

Albert Sauveur had heard in his student days of these early experiments and about 1892 he was given permission to study the heat treatment of steel rails at the South Chicago Works of the Illinois Steel Company. It was about this time that the term Metallography began to be applied to the young science. In 1893 Sauveur published before the A. I. M. E. a paper entitled, "The Microstructure of Steel." In 1896 he wrote another paper for the same society entitled, "The Microstructure of Steel and the Current Theories of Hardening." In it he summarized up-to-date the ideas of various metallurgists as to the reasons of the hardening of steel. The work described in these papers marked the beginning of the application of metallography in the United States.

Meanwhile LeChatelier had given to the world his famous thermocouple pyrometer which opened the way to the scientific study of the effects of high temperature on the structure of metals.

In 1897, Sauveur was called to Harvard University as Instructor in Metallurgy and Metallography and there began his long career that made him one of the foremost metallographists in the world and pioneer in that science in the United States.

Henry M. Howe, first at the Massachusetts Institute of Technology and later at Columbia University, had also begun his profound study of metallographic phenomena and in Europe Akerman, Moissan, Curie, Kohlrausch, Hadfield, Hatfield, Hopkins, Heyn, Law, Stead, Matweiff, Guillet, Ewing and Rosenhain were also beginning their important work.

Roberts-Austen in England and Roozeboom in Holland, Brinell and Benedicks in Sweden and Charpy in France were contributing also to the science.

The beginning of systematic experimentation on alloy steels between the period of 1890 and 1900 and the appearance of high speed steel in 1900 added to the interest in metallographic research which had been started by the important developments of the Bessemer and open-hearth steel making processes.

A new magazine entitled *The Metallographist* edited and published by Albert Sauveur in the United States appeared in January 1898. This magazine and its successor, the *Iron and Steel Magazine*, were very popular, but they have now been out of print for many years.

In 1903, H. M. Howe published his "Iron, Steel and Other Alloys," dedicating this to Tschernoff, "the father of the metallography of iron."

Definition of Physical Metallurgy. Osmond, in an article in the first issue of *The Metallographist*, entitled "Metallography Considered as a Testing Method," says, "Metallography, generally speaking, signifies the description of the structure of metals and of their alloys. The science is not confined to the use of a single instrument, the microscope for instance. In reality we begin by using our eyes in the examination of metals, and when they have shown us all that they can see, we provide them with lenses of increasing magnifying power, until we are stopped, before the mysteries of the ultra-microscopic. But the naked eye and the optical instruments are only an incomplete means of investigation. They take, so to speak, a first inventory; the indications furnished by the visible characters, form, color or luster must be controlled by chemical analysis, microchemistry and crystallography, by the determination of physical and mechanical constants; in a word, by all the available means for the differentiation and identification of bodies."

Osmond early recognized what is now so clear to us that every available tool must be used to solve the mysteries of the behavior of metals. Metallography now includes not only the visual and microscopical examination of metals, but also their study by means of so-called thermo analysis, which involves the experimental determination of heating or of cooling curves and the consideration of constitutional and temperature concentration diagrams of the alloys. The magnetic behavior of metals and the results obtained with the use of the X-ray spectrometer have more recently added to our knowledge. Metallographists must be familiar with methods of testing dilatation and the so-called mechanical properties, the making of calorimetric and pyrometric measurements, measurements of electrical conductivity and in fact all of the physical, chemical and mechanical properties of metals and their alloys. The science is now often called Physical Metallurgy for this reason.

Physical metallurgy, then, may be defined as that science which deals with the study of the physical properties of metals and alloys with special reference to their microstructure.

Early Developments of Metallographic Equipment. Sauveur had in 1894 redesigned the microscope then available to fit it better for metallographic work. He made the stage movable vertically and used this motion for making coarse adjustments of focus. This permitted the instrument to be used with a fixed source of artificial light without the necessity of moving the light source every time a specimen was focused. This design of microscope is still in wide use although it has been greatly improved in mechanical and optical details. In 1896 LeChatelier described his new type of "Microscope for the examination of opaque bodies." This is the now well-known inverted type where the stage is placed above the object making it unnecessary to mount the specimen. The modern LeChatelier type microscopes all have an important improvement suggested originally by Dr.

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* Slightly abridged from a paper presented before the World Engineering Congress, Tokyo, Japan, October 1929.

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Sauveur, namely, an eyepiece tube which pushes in and pulls out, thus bringing into the path of the light beam a totally reflecting prism which reflects the image of the specimen to the eye of the visual observer when the tube is pushed in.

Charpy, as early as 1897, had published an article on "The Microscopic Study of Metallic Alloys" and Madam Curie in 1898 published her famous paper on "The Magnetic Properties of Hardened Steels." Stead had written an article on the "Micro-Chemical Examination of Lead Antimony Alloys" and had published his early work on the "Crystalline Structure of Iron and Steel" in which he called attention to the coarse grain structure now associated with the phenomenon known as "Stead's Brittleness" which he was to develop considerably farther in later writings. In June 1899, LeChatelier had written on the "Dilatation of Metallic Alloys." In 1899, Ewing and Rosenhain delivered a lecture before the Royal Society of London on "The Crystalline Structure of Metals" and studied the question of slip bands while in 1900 Osmond wrote his famous paper on "The Crystallography of Iron" and in 1900 Roozeboom published his article on "Iron and Steel from the Point of View of the 'Phase Doctrine.'"

In 1900 high-speed steel was first exhibited publicly at the Paris exposition and this alloy steel immediately brought about an increased interest in metallographic methods. Jüptner[1] and LeChatelier[2] called attention to the application of Gibbs' theory of phases while Roozeboom[3] first made an important application of the phase rule in a famous paper in which the thermal examination of iron and steel by Roberts-Austen[4] was utilized in the construction of a complete diagram of the thermal equilibrium of iron and carbon. In 1904 the work of the Alloys Research Committee was transferred to the National Physical Laboratory which has turned out many fine pieces of research. In 1903, a memoir by Tammann[5] appeared in which it was shown that very valuable information as to the nature of the equilibrium of the components could be obtained from an investigation of the thermal behavior of alloys.

In 1904, two new periodicals appeared, *La Revue de Metallurgie* in France, and *Metallurgie* (later *Ferrum*) in Germany, the former representing the school of LeChatelier and the latter that of West and Friedrich.

The famous paper, "On the Crystallography of Iron," by Osmond and Cartaud, was reprinted in *The Metallographist*, **4**, 119 (1901). On page 150 of the same volume of *The Metallographist* appeared the important article by Osmond entitled, "Iron and Steel from the Point of View of the 'Phase Doctrine,'" and on page 161 appeared an important article by LeChatelier bearing the same title and in which they deal with the work of Roberts-Austen and Roozeboom.

In 1901, was also established what is now called the United States Bureau of Standards. This Bureau has contributed and is still contributing an immense amount of experimental data to the science.

Beginning about 1905 the developments in the automotive industry, calling as it did for more and better alloy steels, did much to promote the science of physical metallurgy and a great mass of data now exists, so great in fact that a committee has been appointed under the auspices of Engineering Foundation to study and classify the literature on alloy steels and to promote new research with the object of filling the gaps in our knowledge about these important alloys.

In 1911, Ruff[6] and Goecke published an account of the discoveries they made in regard to the solidification of carbon-iron alloys. In the same year, Giolitti[7] described his new process for the case hardening of steel by means of compressed gases. This led to much experimentation in that field and has resulted in the adoption at a number of plants, notably those making roller bearings, of the process of carburizing steel objects with gas. The production in America in 1910 of some 567,000 tons of alloy steels will give some idea of how the use of alloy steels was increasing. Johnson's[8] paper, "Effect of Carbon on the Quality of Cast Iron" in 1913, promoted the study of the physical metallurgy of the cast iron group.

In 1912, Sauveur's[9] discovery that if soft steel be subjected to a certain critical strain, it becomes especially liable to grain growth during subsequent heating for a long time at low temperatures, reopened the study of so-called Stead's Brittleness.

Portevin[10] and Bernard discovered that events which might occur during the forging of steel will produce the structure known as "Widmanstätten," usually associated with steel castings. These events are: too long a sojourn in the zone where austenite is normal, and too rapid cooling during the separation of ferrite and cementite, i. e., during secondary crystallization. Belaiew[11] contributed a study of the crystallization of steel and of the Widmanstätten structure which caused the Russian artillery to announce that the visibility of the Widmanstätten structure at any magnification up to 50 diameters is sufficient cause for rejecting the material.

Desch had in 1910 published his textbook on "Metallography" which added much to our theoretical knowledge of the science and the book has now gone through three editions. In 1912, Sauveur published the first edition of his "Metallography of Iron and Steel," whose title later was changed to "Metallography and Heat Treatment of Iron and Steel." It has been through three editions and several reprints. This book is now in world-wide use and forms the foundation upon which many metallographists base their education.

In 1915, Howe published his monumental work, "The Metallography of Steel and Cast Iron."

Steel Hardening Theories. Since 1896 when Sauveur had published his paper entitled, "The Microstructure of Steel and Current Theories of Hardening," there had been much heated discussion as to the reason for the hardening of steel by quenching from above the critical range. Some ten or twelve distinct theories have been formulated by as many investigators and these were described and commented upon in some detail by Sauveur in the second edition of his book. In September 1919, in describing a study of the "Heat Treatment and Constitution of Duralumin," Merica[12], with Waltenberg and Scott, pointed out that the hardening of duralumin by quenching and tempering (aging) was apparently due to what they called a critical dispersion of very fine hard particles of $CuAl_2$ in the ground mass of a solid solution of $CuAl_2$ in aluminum. This phenomenon was checked and confirmed by others. Merica and his associates also drew an analogy between the hardening of duralumin and the hardening of steel and their bold theory of hardening by critical dispersion of hardened particles in a softer matrix formed the basis, together with confirming work of their own and their associates, of the well-known slip-interference theory of the hardening of metals promulgated by Jeffries[13] and Archer.

Another storm of criticism, discussion and experimental work ensued. An epoch-making paper was published by F. F. Lucas[14] of the Bell Telephone Laboratories, entitled, "The Microstructure of Austenite and Martensite," in which he showed the practicability of using very high magnifications in photomicrography (3000–6000 X) and discussed the experimental determination of the nature of martensite. Prompted by the discussion which this paper provoked, a meeting was held in connection with a convention of the American Society for Steel Treating in September, 1924, in honor of Dr. Kotaro Honda, the distinguished Japanese metallurgist and director of the Department of Metallurgical Research, Tohoku Imperial University, Sendai, Japan.

As a result of the discussion on the nature of martensite at this meeting Sauveur propounded a questionnaire which was participated in by some twenty-three eminent metallurgists from Japan, England, France and America.

The answers to these questions together with Sauveur's own opinion on the matter were published.[15] There were nearly as many different answers as there were answers to the questionnaire. Sauveur stated his belief that martensite is an aggregate of austenite and troostite necessarily resulting from the gradual transformation of austenite into troostite. He also called attention to the fact that the very acicular structure of martensite, as pointed out by Thompson, acts as a strengthening scaffold throughout the mass.

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[1] *Stahl und Eisen*, **19**, 23 (1899).

[2] *Compte rendus*, **130**, 85 (1900).

[3] *Zeitschrift physikalishe Chemie*, **34**, 437 (1900); *Journal Iron and Steel Institute*, **1900**, No. II, page 311.

[4] *5th Report to Alloys Research Committee, Proceedings Institute Mechanical Engineers*, **1899**, page 35.

[5] *Zeitschrift anorganische Chemie*, **37**, 303 (1903).

[6] *Metallurgie*, July 22, 1911.

[7] *Journal Iron and Steel Institute*, **1911**, no. II.

[8] *Trans. A. I. M. E.*, **1912**.

[9] *Proceedings International Assoc. for Testing Materials*, **1912**.

[10] *Revue de Metallurgie*, **1912**.

[11] *Revue de Metallurgie*, **1912**.

[12] *Trans. A. I. M. E.*, **64**, 41 (1920), also as *Publication of Bureau of Standards Tech. Paper*, **1919**, page 347.

[13] *Chem. and Met. Eng.*, June 15, 1921, page 1057.

[14] *Trans. A. S. S. T.*, **6**, 669 (1924).

[15] "The Current Theories of the Hardening of Steel Thirty Years Later," *Trans. A. I. M. E.*, **73**, 859 (1926).

In 1927, Sauveur[16] gave the following simple and logical explanation of the hardening of steel by rapid cooling. It is believed that this theory is that best supported by experimental evidence and may be as complete an explanation as can ever be had. Sauveur believes that martensite is an aggregate of austenite and troostite forming a true Widmanstätten structure, that the aggregate consists of austenite, which is a super-cooled solid solution of iron carbide (or carbon) in gamma iron, and troostite, which is a super-saturated solution of iron carbide in alpha iron, the troostite being precipitated along the octahedral cleavage planes of the austenite, thus forming the Widmanstätten structure. Sauveur believes that the hardness of the martensite is due to the following: (1) to the hardness inherent to martensitic type of structure; (2) to the fineness of the structure; (3) to the hardness of both the alpha and gamma phases. Sauveur also believes that the presence of severe internal strains in martensitic steel may also be a contributory cause of the hardness. His theory is not irreconcilable with Jeffries' and Archer's slip interference theory, however, which also holds that the hardness of quenched steel, that is, the hardness of martensite, is due in a large measure to the fineness of this structure. While Sauveur's explanation is believed by the writer to be one of the simplest and most complete of the theories that have been offered, due credit should of course be given to Jeffries and Archer, to Howe, Osmond, Lucas, Merica and others whose work made it possible to develop this theory.

Crystalline Growth in Metals. A renewed interest in the metallography of brass and other copper alloys was developed by the publication of a paper by Mathewson and Phillips entitled, "Recrystallization of Cold Worked Alpha Brass on Annealing."[17] Not long after Jeffries[18] published his important paper entitled, "Grain Growth Phenomenon in Metals," and Howe[19] also published his article on "Grain Growth." At that time Carpenter[20] and Elam wrote on the "Crystalline Growth and Recrystallization in Metals" and Edwards[21] and Pfeil published an article on "Production of Large Crystals by Annealing Strained Iron." "Grain Growth in Silicon Steel" was studied by W. E. Ruder.[22] This work on the crystalline growth of metals had no doubt been inspired by Stead's early work already referred to, and an article by Sauveur[23] "Crystalline Growth of Ferrite."

Neumann Bands. Certain markings in meteoric iron were first noticed by Neumann in 1848 and later in commercial iron by Prestel. Sauveur had published a note or two on this phenomenon and the subject later became of such general interest that in 1919 a committee was appointed by the National Research Council with the object of determining, if possible, whether this phenomenon could be produced at will, and the connection between its existence and the speed of breaking of the metal. The results of the investigation were printed in a paper by Foley[24] and Rowell before the American Institute of Mining and Metallurgical Engineers in an article entitled, "Neumann Bands as Evidence of Action of Explosives on Metals," and later Foley[25] and Grawshaw reported on "Effect of Air Gap in Explosive System on Production of Neumann Bands," while Rosenhain[26] and McMinn read a paper before the Royal Society entitled "Plastic Deformation of Iron and the Formation of Neumann Lines."

The Iron-Carbon Diagram. As early as 1896 Sauveur[27] in a paper entitled "Microstructure of Steel" showed diagrammatically the relation of pearlite, ferrite and cementite to the thermal critical points and Roberts-Austen[28] in his Fifth Report to the Alloys Research Committee indicated that, in the higher carbon alloys, either graphite or cementite could be present as one member of the eutectic. In 1900, Roozeboom[29] in his article on "Iron and Steel from the Point of View of the Phase Doctrine" called attention to the fact that the occurrence together of cementite and graphite in iron-carbon alloys could not occur in a system in a state of equilibrium and presented his conception of the position of the curves in what is now known as the Iron-Carbon Diagram. While Howe has expressed the opinion that credit for the first equilibrium diagram of the iron-carbon alloys is due to Reinhard Mannesmann, the writer cannot find any reference to any published work of his. So that with this possible exception Sauveur had the honor to publish in 1896 the first equilibrium diagram covering that portion of the field where the thermal critical points occur, while Roberts-Austen published in 1897 an equilibrium diagram which included the liquidus and solidus and again in 1899 published a revised diagram, while Roozeboom's diagram, which very nearly resembles the one now generally accepted, was published in 1900. Stansfield[30] also published his views together with an iron-carbon diagram in which he maintained that at ordinary temperatures ferrite and graphite were the stable phases present. Carpenter and Keeling in 1904 made a series of very careful experiments to ascertain the evolution of heat taking place in cooling pure iron-carbon alloys from the liquid state to atmospheric temperature and published a revised equilibrium diagram. Later on Benedicks,[31] summarizing the previous work including that of Heyne[32] and Bauer and Charpy[33] and Grenet proposed a double diagram: (1) the stable, austenite and graphite; (2) metastable, austenite and cementite. This was an excellent working hypothesis until Gorens[34] showed that all pure cast irons solidified as austenite and cementite and that graphite was the product of the decomposition of cementite and was not an original constituent. Later the work of Wittori[35] indicated two new carbides, Fe_4C and FeC_2. Later on Guertler[36] proposed a new diagram and at the same time discussed changes in the diagram proposed by Smits, Hanemann and others. Still later Ruer[37] and Klesper suggested the existence of a new form of iron known as Delta iron and this was checked by Honda[38] who also showed that the line MO, marking the position of the A_2 change indicating the maximum magnetic change, should be continued across the diagram in the whole system, and maintained that Beta iron has no place on the diagram.

The foundation having been laid by the early work on iron and steel, work on the copper-aluminum, copper-tin and copper-zinc soon followed but the bulk of the data on non-ferrous alloys as on alloy steels is of much more recent date.

It would be impossible here to record individually the work done by the many investigators in these lines but the *Transactions of the American Institute of Mining and Metallurgical Engineers* and the *Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers*, the *Journal of the British Iron and Steel Institute* and the *Journal of the British Institute of Metals*, for the last twenty years, are full of valuable articles dealing with the constitution and properties of many ferrous and non-ferrous alloys.

The Research Institute for Iron and Steel, attached to the Tohoku Imperial University, Japan, has published nearly 200 papers on various metallurgical subjects.

In 1920, on account of the demand for space for publication of articles dealing with the metallography and heat treatment of iron and steel, there was formed the American Society for Steel Treating. This was the outgrowth of the union of two smaller societies. During the last nine years this society has grown to a membership of approximately fifty-five hundred. Each year this society publishes many reports of original investigations, and some written especially from an educational standpoint for those of the members who have not had a complete college training. The Society has some thirty-two local chapters. In the publications of these various technical socities there are appearing and will appear the articles recording the research work which will make the history of the next fifty years of physical metallurgy.

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[16] *Proc. Am. Philosophical Soc.*, **66**, 267 (1927).
[17] *Trans. A. I. M. M. E.*, **54**, 608 (1916).
[18] *Trans. A. I. M. E.*, **56**, 571 (1917).
[19] *Trans. A. I. M. E.*, **56**, 582 (1917).
[20] *Jr. British Institute of Metals*, **24**, 83 (1920).
[21] *Jr. British Iron and Steel Institute*, **1924**, No. 1, page 129.
[22] *Trans. A. I. M. E.*, **47**, 569 (1913).
[23] *International Association for Testing Materials*, **2**, 6 (1912).
[24] *Trans. A. I. M. E.*, **68**, 891 (1923).
[25] *Trans. A. I. M. E.*, **73**, 948 (1926).
[26] *Proc. Royal Soc. A.*, **108**, 231 (1925).
[27] *Trans. A. I. M. E.*, **22**, 863 (1896).
[28] *Proc. Inst. Mech. Eng.*, **1899**, page 35.
[29] *Journal Iron and Steel Institute*, **1900**, No. 2, page 311; *Metallographist*, **3**, 293 (1900).

[30] *Journal Iron and Steel Institute*, **2**, 317 (1800); *Metallographist*, **3**, 300 (1900).

[31] "Über das Gleichgewicht und die Erstarrungsstrukturendes Systems Eisen-Kohlenstoffe," *Metallurgie*, **3**, 393 (1906).

[32] "Stabile und Metastabile Gleichgewichte in Eisen-Kohlenstoff-Legierungen," *Zeitshrift für Electrochemie*, **10**, 491 (1904); "Zur Metallographie des Roheisens," *Stahl und Eisen*, **27**, 1565 (1907).

[33] "Sur L'equilbre des systemes fer-carbone," *Bull. Soc. d'Encouragement*, **1902**, page 399.

[34] "Über den Augenblicklichen Stand unserer Kenntnisse der Erstarrungs und Erkaltungsvorgänge bei Eisenkohlenstoff-Legierungen," *Metallurgie*, **3**, 175 (1906); **4**, 137 (1907); **5**, 137 (1908).

[35] "Recherches sur les alliages de fer et carbone," *Revue de Metallurgie*, **9**, 600 (1912).

[36] *Metallographie*, **1**, Pt. 2 (1912).

[37] "Der J-Umwandlung des reinen Eisens und ihre Beeinflussung durch Kohlsenstoff, Silizium, Kobalt, und Kupfer," *Ferrum*, **11**, 257 (1914).

[38] "On the Constitutional Diagram of the Iron-Carbon System," *Sci. Rep. Tohoku Univ.*, **11**, 119 (1922).

Correlated Abstracts

Dr. Gillett, the editorial staff and specially selected contributors will prepare abstracts reviewing the work recently reported pertaining to certain subjects. These reviews will take into consideration the work of a number of workers. The current literature will be covered in the Abstracts of Current Metallurgical Literature.

More on Fatigue and High Frequency Fatigue Testing

There have previously appeared in METALS & ALLOYS, reviews of and comments on recent work on endurance.[1] Two more important articles now demand attention. Professor Moore[2] sums up the present situation in regard to fatigue testing with his usual clarity. His paper should be read by everyone interested in fatigue, as it sums up in broad outline what real knowledge exists on that subject to date.

The other paper is by Jenkin and Lehmann[3] and describes a method of highly accelerated fatigue testing.

At the highest speeds, ten million cycles of stress may be imposed upon the specimen in less than 15 minutes. This paper may be epochal, as heralding the advent of true accelerated fatigue testing. On the other hand, the difficulties involved are many, and time may show that not all that the authors indicate as probable can ultimately be accepted. More work is required by other investigators before we can take this work as gospel truth.

The method used is to take a small flat strip of metal which has a high natural period of vibration, suspend it at its nodes by drilling and inserting tiny wires and blowing air against it from a nozzle consisting of a disk with a central air passage. Instead of just blowing the strip away from the nozzle, if the nozzle and strip are close together, a partial vacuum is produced at the surface of the strip, and pressure further away, something analogous to the distribution of air pressure about an airplane wing. If the strip is started vibrating, it acts as a valve to the air jets, takes up its natural period of vibration due to its dimensions and elastic properties, and causes the energy imparted by the air blast to act on the specimen at a definite periodicity.

The design of the apparatus is not so simple as it sounds, and a long series of changes, described by Jenkin and Lehmann, were necessary before a suitable nozzle and suspension were worked out. The last and most successful nozzle is quite similar to that used by the Mechanics and Sound Division of the Bureau of Standards which has also been working on this problem for some years.

Incidentally, it seems odd that Jenkin and Lehmann's article makes no mention of the simultaneous work of the Bureau on the problem. While the Bureau's work is yet unpublished, the apparatus at Washington has been shown to several British visitors interested in high speed fatigue. We shall comment later on some differences in the American and British set-ups and results.

Jenkin and Lehmann used specimens of about 0.1 cm. thick, 0.3 cm. broad and from 1.7 to 7.25 cm. long. The specimen for the highest speeds is then, roughly $^1/_{24}''$ thick, $^1/_8''$ broad and $^3/_4''$ long, a very tiny specimen indeed. The frequency depends chiefly on the length. The density, the modulus of elasticity and Poisson's ratio all enter into the frequency, and into the rather complicated mathematical calculations necessary for computation of stress. The authors point out that the experimental evidence indicates that the modulus of elasticity varied with frequency, and that materials under these conditions of stress are not perfectly elastic anyway. Poisson's ratio is a much neglected property of materials, and is seldom known very exactly.

The mathematical theory of vibration at first indicated to Jenkin and Lehmann that the air machine would not work because of anti-elastic or wavy bending (look it up in the big dictionary if you're interested, the reviewer had to), but by referring the matter to a mathematician, Professor A. E. H. Love, they were reassured, and two formulae given for computation of stress. The reviewer is not competent to pass on the mathematics or the assumptions involved, but gathers that the authors feel that while the calculated stresses may not be quite right, they are not far off.

On the other hand, some tests were run on 0.11% C normalized steel with specimens 1.27 cm. broad instead of 0.3 cm. The calculated results for the same frequencies were as shown below.

	Endurance limit (Stress to break at 10 million cycles)	
Frequency	Broad Specimen	Narrow Specimen
1100	35,500	33,500
5500	41,000	37,500
10,000	51,500	39,500
15,000	....	40,500

It is not clear to the reviewer just how sure one may be that the stresses calculated for the narrow specimen are true. The endurance limit in all the tables is evidently the calculated stress that will give a life of about 10 million cycles, quite irrespective of whether the specimen will break if stressing is continued. For example, a bar run at a calculated stress of 17.45 tons/in.², broke at $10^1/_2$ million cycles. Another was run for only a few more cycles at 17.38 tons and was unbroken. Again, one broke at 23.15 tons after $8^1/_2$ million cycles and no higher stresses being used, the endurance limit is listed as 23.15 tons.

Turning to the tests on aluminum, it is to be noted that the "fatigue limit" is given on the basis of bars run only to 10 or 11, or in one case $15^1/_2$ million cycles.

It will be recalled that J. B. Johnson[4] finds that at least 500 million cycles are required in aluminum and its alloys to give a figure that will serve for aircraft design, and even then, there is doubt whether a real fatigue limit has been reached. At the frequencies chiefly used by Jenkin and Lehmann, it only took about half an hour or less to run off 10 million cycles. It seems inexcusably sloppy work to quit at 10 million cycles or so in this investigation.

It is known that at the low frequencies of ordinary testing, a run of 10 million cycles is enough on hard steel, scarcely enough on very soft steels, but it is not at all known that it is enough at these frequencies, and it is very definitely known that it is not enough for aluminum or copper. If the criterion for the fatigue limit had been a billion cycles instead of 10 million, no one knows

Material	Condition	Tensile Strength Lbs./In.²	Brinell[a] No.		Fatigue Limits (10 Million Cycles) Lbs./In.² Using Specimen 0.3 cm. Broad, at Frequencies Shown Periods/Sec.					
0.11 C steel	Normalized	50500	101	Freq.	50	1100	5500	10000	15000	
				F. L.	32000	33500	37500	39500	40500	
0.11 C steel	As rolled	96500	200	Freq.	50	1100	5500	10000	15000	
				F. L.	51000	52000	53500	55000	56500	
Armco iron	Normalized	45000	85	Freq.	50	920	4600	8400	12400	16500
				F. L.	31000	33500	37500	40500	40500	39500
0.86 C steel	Water quenched from 800° C.	112000	550	Freq.	50	5000	9200	13600	18200	
	Not drawn			F. L.	49000	63000	72500	71500	66000	
Copper	Annealed	33000	38	Freq.	50	660	3200	5900	8800	
				F. L.	10500	11000	13000	12500	12500	
Aluminum	As rolled	14500	38	Freq.	50	5000	9200	14100	18400	
				F. L.	8500	10000	10500	11000	11000	

[a] Baby Brinell, small balls and small loads.

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[1] Vol. 1, pages 19, 21, 70, 92, 95, 116, 117.

[2] H. F. Moore, "The Fatigue of Metals"—a review of progress from 1920 to 1929, *Preprint, Am. Iron and Steel Institute*, October 25, 1929.

[3] C. F. Jenkin and G. D. Lehmann (Oxford), "High Frequency Fatigue," *Proc. Roy. Soc. (London)*, Ser. A, **125**, No. A796, Aug. 1, 1929, pages 83–119.

[4] METALS & ALLOYS, July 1929, page 22.

whether the increase in endurance limit with speed of testing claimed by Jenkin and Lehmann would still show up or not.

On the face of their results, the (10 million) fatigue limit *rises* with increase of frequency, and in some cases, then *falls* with further increase, but up to the highest frequencies tried, does not drop back to the figure found at low frequencies in ordinary fatigue testing.

Results are given in table at foot of preceding page (stress figures being rounded off in calculating ton/in.^{2} in which the data are reported, to lbs./in.^{2}).

The 50 period/sec. frequency was not determined by the air jet method, but is the fatigue limit as determined by more common methods. It is not stated whether these base-line figures were actually determined for these lots of metal.

There is a hint in the data for Armco iron that at the highest frequencies the endurance limit falls, and, on the face of the data, it certainly appears to do so for the quenched but not drawn eutectoid steel. But it was assumed that the temperature of the specimen remained at room temperature during the test, on account of cooling by the air blast. This is certainly not proven. Indeed, some observations are given which would be consistent with extreme heating at very localized points of microscopic dimensions within the specimen. Where the fatigue limit reached a maximum and then fell, at the highest frequencies, the fractures at frequencies above that for maximum fatigue limit were thought to be intercrystalline instead of transcrystalline. The hardness of the specimens increased during test up to some high frequency and with still higher ones, fell again.

These points of metallurgical interest are given only in qualitative fashion, and Jenkin and Lehmann class them as "suggestive" only. They admit that imperfect elasticity may affect the shorter, higher frequency bars more than the longer, and that a systematic error may thus be introduced. Hence the drop in fatigue limit at the highest frequencies cannot be taken as proven.

All the tests of Jenkin and Lehmann indicate that at least up to a very high frequency, the fatigue limit increases with frequency. From the practical point of view, this means (1) that fatigue limits determined at low frequencies are safe for design at much higher frequencies, (2) that if high frequency testing is to be used to get design figures for use at low frequencies, a correction will have to be made, as the high frequency figure would be too high and unsafe for design use. Since the correction is not the same for different materials, low-frequency testing will have to be resorted to, to establish the correction, and much of the potential usefulness of the rapid method is lost.

The increase in fatigue limit with frequency agrees with earlier work by Jenkin on copper (the curves are not identical, but are parallel).

Were it not that the unpublished work at the Bureau of Standards shows the exactly opposite condition, the work of Jenkin and Lehmann would appear to be quite conclusive. At the Bureau, in work with aluminum and duralumin in specimens of much larger dimensions than those used by the English workers, so that the actual shape of the bent specimen and hence, the stress can be more closely determined, supporting the specimens on air jets instead of by wires, and driving them with air jets very similar to the final English form, the endurance curves fall *below* those at ordinary frequencies. This being the case, we may be grateful to the English workers for their description of the experiment, but should be a bit chary of accepting their conclusions without further verification.—H. W. GILLETT.

Electrolytic Methods for the Extraction of Non-Metallic Inclusions from Steel

The presence of non-metallic inclusions in steel has been thought to be the cause of a large number of defects and failures of steel in use. Because of this belief many investigations have been made dealing with the type, and particularly the amounts, of impurities present. An investigation at the Pittsburgh Experiment Station of the United States Bureau of Mines, in cooperation with Carnegie Institute of Technology and the Metallurgical Advisory Board, has been directed with the hope of quantitatively determining the amount of inclusions present in steel.

A large number of extraction methods has been proposed, which has met with only a small degree of success. Some of the reasons for the failure of these proposed methods are that a large number of inclusions are soluble in the reagents and frequently such small samples are used that insufficient residue is obtained for the subsequent analysis of the non-metallic matter. Likewise, no method has been recommended which offers any means of accurate control of the rate of solution of the steel, the solubility of various inclusions, and the type of contamination of the extracted material which necessitates subsequent treatment for removal.

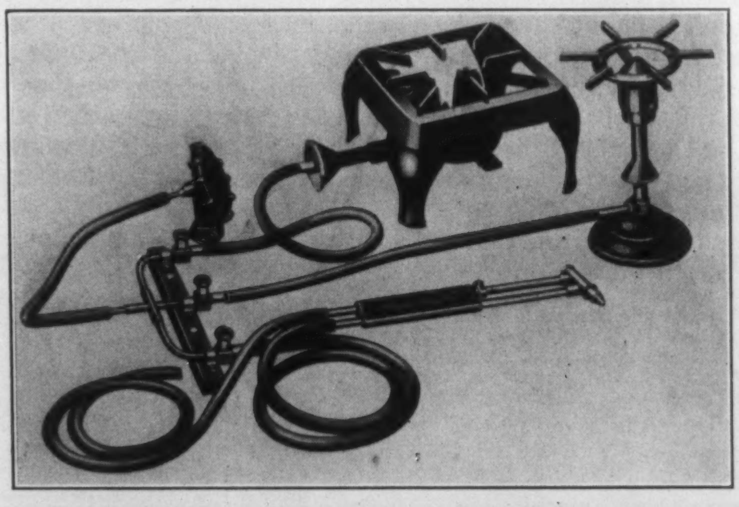
Certain electrochemical principles do, however, offer means for controlling the above factors in such a way that by proper selection of electrolytes, inclusions should be quantitatively extracted from steel and merely require washing and drying to complete the determination. Therefore, a method could be devised by the proper selection of an electrolyte, which, of course, involves considerable theory and experimentation. From the work already done in this connection, it is known that the electrolyte desired must have a hydrogen ion concentration practically that of water. This in turn necessitates the combination of (OH)$^-$ ion in a soluble complex so that ferrous and ferric hydroxides will not be precipitated. Also, both the H$^+$ and (OH)$^-$ ion concentrations must be maintained as constant as possible. An electrolyte of this type necessitates a buffer solution containing a weakly ionized acid and some material such as sodium citrate. Another year of investigation should solve this problem, and in doing so greatly further the larger problem of the formation and identification of inclusions in steel.

A Convenient Source of Intense Heat for Laboratory Work

Plants maintaining testing laboratories of various sorts do a great deal of their experimental and research work with the aid of small flame apparatus.

The flame can be easily controlled and is hot enough to melt various metals. A most convenient and complete laboratory installation consists of a small tank of dissolved acetylene; a hot plate; a Bunsen burner; on acetylene-and-air torch with air control; a reducing valve; a three way branch valve, and the necessary red gum tubing.

With this outfit all manner of laboratory tests can be undertaken. Dissolved acetylene has many distinct advantages over liquid or other gas fuels. It not only produces a higher flame temperature than coal gas or natural gas, but forms a flame that can be perfectly controlled. This flame is non-oxidizing and non-carbonizing as well.



A special type of torch has been developed for test work and uses compressed air in addition to dissolved acetylene. The flame may be changed from the brush type to an intense needle point by adjusting the air supply. This accomplished by a simple twist of the adjusting screw. The brush, or bunsen flame, has a temperature of approximately 2800° F. and the needle point flame produces approximately 3300° F., making it suitable for any work requiring high temperature. A wide latitude of temperature control is possible by adjustment of the gas pressure, providing a range of heat in many metals, from near melting, to the molten stage.

The hot plate and bunsen burner recommend themselves by their convenience, cleanliness and intensity of the flame. They save time and keep instruments and utensils free from soot and smoke. The outfit is supplied by the Prest-O-Lite Co., 30 East 42nd St., New York, N. Y.

Critical Abstracts

Dr. Gillett, the editorial staff and specially selected contributors will prepare abstracts of a critical nature on articles of special importance. The current literature will be covered in the Abstracts of Current Metallurgical Literature.

The Relation between Alpha-Veining and the A_3 Change in Iron*

By E. Ammermann and H. Kornfeld

The term "α-veining" has been used to describe the structural feature of ferrite illustrated in the micrograph, Fig. 1. The veining appears as a network *within* the grains which in the micrograph are outlined by the darker boundaries. This term appears to have originated with Robin.[1] The name "sub-boundaries" is preferred by some, especially the English metallurgists.

This phenomenon, along with other unusual features in the microstructure of ferrite has been discussed in considerable detail in a recent publication of the Bureau of Standards.[2] This feature of the structure of iron has been known for a good many years, the first published description appears to be that of Andrews.[3] O. W. Storey's suggested explanation, based entirely upon observations of the microstructure of remelted electrolytic iron,[4] comes very close to the view which is held to-day as to the nature of this phenomenon. He said: "If we consider that, owing to the large gamma grains, a large number of non-gamma nuclei were formed in each gamma grain and that each nucleus was similarly oriented, owing to similarly oriented gamma grains, we can readily see that the ferrite grains would be composed of a large number of similarly oriented crystals."

The results of a recent study of this subject by Ammermann and Kornfeld,[5] have served to supplement in an admirable manner the work of Rawdon and Berglund and to explain in an undisputable manner some points which were left unsettled. The conclusion of Rawdon and Berglund that "the formation of veining is definitely to be associated with the allotropic or α-γ change in ferrite "can in light of the recent results be restated, as follows: "Veining in ferrite grains forms *only* if the iron is transformed from the α into the γ condition." Rawdon and Berglund also concluded that "ferrite mechanically worked at or below the temperature of the α-γ transformation shows veining in abundance, whereas the same material forged at a higher temperature usually shows very little veining." Ammermann and Kornfeld have shown very clearly the relationship existing between mechanical working of iron below A_3 and the tendency toward veining formation. Their results show that mechanical deformation below A_1 or between A_1 and A_3 for a low-carbon steel, as well as for electrolytic iron below A_3, does not result in veining. If some veining is present, however, mechanical deformation accentuates the condition.

Some of the Ammermann and Kornfeld results are tabulated below:

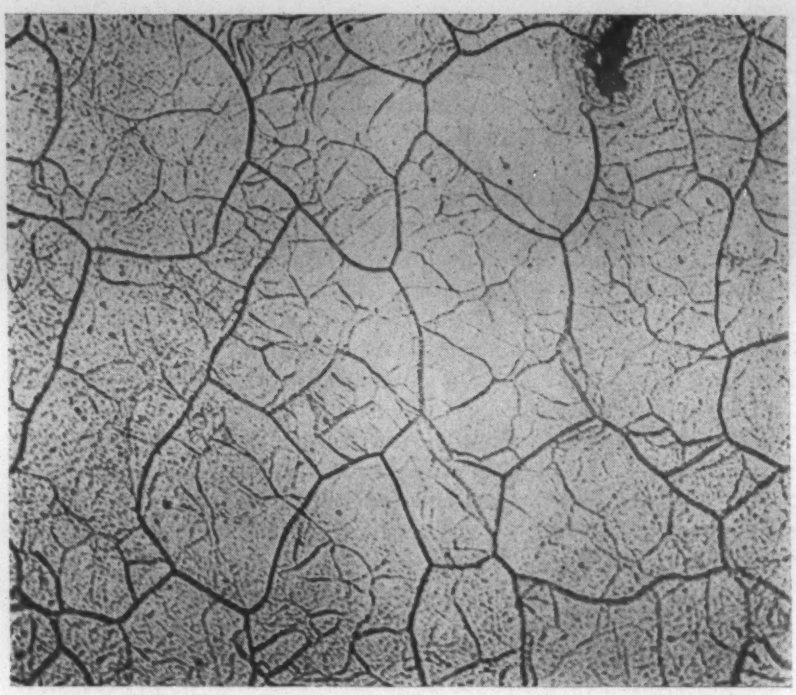


Fig. 1.—Microstructure of Remelted Electrolytic Iron; × 100; Etchant Picric Acid Solution

Further observations were made on the behavior of the low carbon steel upon heating. As is well known, at A_1 pearlite transforms into the solid solution (γ) condition, i. e., the tiny portions of the metal which constitute the pearlite masses distributed throughout the body of the iron, pass through their A_3 change. Therefore, a low carbon steel immediately above this temperature consists of a mixture of the α ferrite and γ solid solution, the relative proportions of which vary with the temperature. The amount of α ferrite decreases as the temperature is raised and finally disappears, at the temperature which is usually considered as the A_3 for the particular steel. This, of course, is true only in the sense that it marks the consummation of the change which started at A_1. As shown below, the low carbon steel used could be rendered free from veining by recrystallization at 750° C. following cold working. When heated above this temperature, veining was found in the structure and the veined areas were considered to be coincident with those portions in which the carbon was distributed. These, of course, would be γ areas at the temperatures used; 800, 850 and 890° C. In the microstructure of specimens of low-carbon steel heated to a temperature just below A_3, was noted a feature which was interpreted to be the "skeleton"

Exp. No.	Material	Treatment	Structural Condition	Conclusion
1	Low-carbon steel (0.13% C, 0.5% Mn)	Air-cooled from γ-state (above A_3)	Veining within ferrite grains very prominent	
2	Low-carbon steel (0.13% C, 0.5% Mn)	Reduced 20% by compression (cold)	"Cold-worked" structure veining still to be seen	Ferrite which is free from α-veining can be obtained by cold working the material and heating it sufficiently long below A_3 to permit recrystallization to occur. (In the case of low-carbon steel, it is necessary to use a recrystallization temperature considerably below A_3)
3	Low-carbon steel (0.13% C, 0.5% Mn)	Treated as in No. 2 heated 2 hrs. 750° C.	Recrystallized, large grains, no veining	
4	Electrolytic iron (not remelted)	Aircooled from γ-state (above A_3)	Veining within ferrite grains	
5	Electrolytic iron (not remelted)	Reduced 10% by compression (cold); heated 1 hr. 850° C.	Recrystallized, large grains, no veining	
6	As in 1	Reduced 10% by compression (cold), heated 1 hr. 750° C.	Some evidence of veining still to be seen in the partially recrystallized structure	
7	As in 4	Reduced 10% by compression (cold); heated 1 hr. 850° C., then 1/4 hr. 880° C.	No veining after 850° C. No veining after 880° C.	Ferrite which is free from veining shows no veining after being heated just below the A_3 ($\alpha \rightarrow \gamma$) chg.
8	As in 4	As in 7 except second heating was 1/4 hr. 910° C.	Veining within ferrite grains	Ferrite initially free from veining, showed veins after being heated just above A_3

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* *Archiv für Eisenhüttenwesen*, Oct. 1929, pages 307–311.

[1] *Traite de Metallographie*, **1912**.

[2] H. S. Rawdon and T. Berglund, *Scientific Paper* **571**.

[3] *Part I, Proceedings Royal Society, London*, **58**, 59 (1895).

[4] *Transactions American Electrochemical Society*, **25**, 489 (1914).

[5] *Archiv. für Eisenhüttenwesen*, **3**, 307, October 1929.

of the untransformed ferrite. By etching with Fry's reagent (which also was used almost entirely throughout the study for revealing the veining) the authors showed that the ferrite skeleton was free from veining, whereas, throughout the body of the specimen, there was abundant evidence of it. These observations were interpreted as strengthening the former conclusion that α-veining originates *only* when ferrite is transformed into the γ condition.

In order to show whether any relationship existed between the tendency toward veining-formation and mechanical deformation samples of the low-carbon steel, previously rendered free from veining, were deformed by being hammered at a temperature of 650° C., that is, below A_1 and at temperatures between A_1 and A_3. Slip bands, but no veining, occurred in the former case. In the latter, abundant veining occurred which was attributed to the fact that since there was carbon present there were also γ areas (as discussed above). The observation that electrolytic iron, free from veining, when hammered in the neighborhood of 880° C. did not develop veining supports this view.

In brief, the authors' conclusions seem to be fully established; (*a*) ferrite free from α-veining can be obtained by the recrystallization, below A_3, of the previously cold-worked material; (*b*) veining occurs only when iron (ferrite) is transformed into the γ condition, (*c*) deformation below A_3 does not cause veining, although it does promote its formation if some veining already exists, as a result of other factors (as in a low-carbon steel).

No information was given nor was any opinion expressed as to the possible practical importance of the phenomenon of veining. In the recent brief summary of this subject in *The Metallurgist*, Supplement to *The Engineer*, October 1929, page 147, the opinion was expressed that "it is by no means certain that this phenomenon may not be of considerable importance, if, for example, it should be connected with the well-understood transformations in iron or if it should be dependent upon some impurities in the iron.

The study of this structural feature in iron of a much higher degree of purity than has been used in any of the studies hitherto would seem to be well worth while in that it may have a distinct bearing on the subject of traces of impurities in iron and their effect on the α-γ transformation.—H. S. RAWDON.

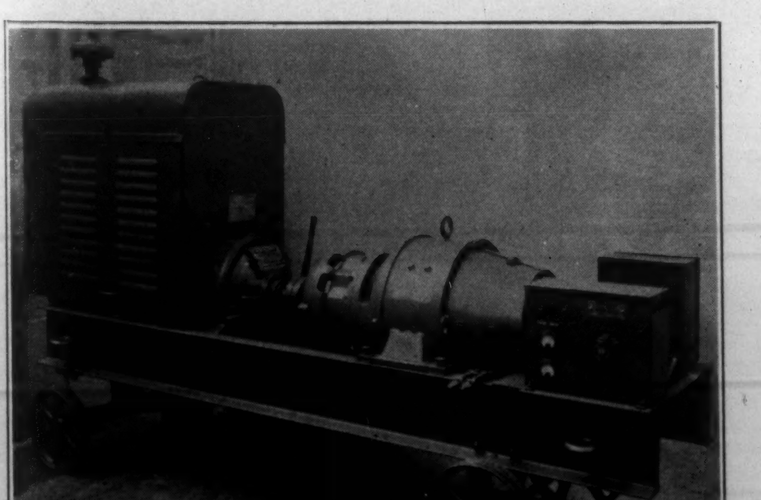
The New Westinghouse Dual Drive Welding Unit

A New Dual Drive Arc Welding Unit has been introduced by the Westinghouse Electric & Manufacturing Company.

The unit consists of a standard 300 ampere single operator welding generator, a 15 hp., alternating current induction motor and a six cylinder 1800 r. p. m. Continental gas engine mounted in tandem on structural steel welded base. The motor operates on 220 volts, but can be adjusted so that it can be used on 440 volts. The welding generator can be driven by either the gasoline engine or the electric motor.

The dual drive welding machine can be furnished in all the popular single operator ratings, stationary or portable.

There are many advantages of dual drive welders for field service, especially when the unit must be moved from one location to another with electric current not always available. The motor can be furnished to operate on practically all industrial power circuits.



The New Westinghouse Dual Drive Welding Unit

Hascrome Welding Rod

The Haynes Stellite Company of Kokomo, Indiana has placed on the market a manganese-chrome-iron welding rod called Hascrome. This is a self-hardening alloy, designed primarily for building up badly worn parts preparatory to surfacing them with Haynes Stellite, which is also supplied in the form of welding rod. Since the cost of Hascrome is materially less than that of Haynes Stellite, the resulting composite surface is much cheaper than if entirely built up of the latter alloy. Hascrome may be used for building up large sections of steel or cast iron, and forms an excellent base for Stelliting because it is sufficiently hard to resist deformation under impact, and because of the ease with which Haynes Stellite flows onto it. Although in some cases Hascrome alone may be used for hard-surfacing parts subject to abrasive wear, it does not possess red hardness to the same degree as Haynes Stellite, and it will wear away more rapidly. The new alloy is also being used for tacking Haystellite—the Haynes Stellite Company's diamond substitute—to the cutting and reaming edges of oil well drilling tools.

The oxy-acetylene process is considered best for the application of Hascrome, since the hardness of the deposited metal can be controlled by the amount of excess acetylene used in the welding flame, as well as by the rate of cooling. The greater the excess of acetylene in the flame and the slower the cooling rate, the harder the deposit will be. When quenched, the metal becomes softer and tougher. Hascrome is applied to steel without puddling the steel. Best results are obtained when the deposit is made just so the steel surface is at a "sweating" heat. The following figures give results obtained under average conditions:

	Brinell Hardness
Small excess of acetylene	
Slowly Cooled	250–300
Quenched	240–290
Heavy excess of acetylene	
Slowly Cooled	450–500
Quenched	350–450

The Hascrome deposit has a tensile strength of 40,000 and a compressive strength of 177,000 lbs./in.^{2} It can be forged and ground, but not machined.

Hascrome welding rod can also be applied by means of the metallic arc process, by the use of reverse polarity, making the rod the positive electrode. Care must be taken to prevent cracking after quenching when this method is employed. Arc-welded deposits have a hardness of 240 to 400 Brinell, depending on the rate of cooling. Better deposits are obtained when a coated rod is used. An excellent coating can be made as follows:

Calcium carbonate	1 oz.
Silica flour	1 oz.
Sodium bicarbonate	1 oz.
Shellac	1 oz.
Alcohol	16 oz.

Hascrome is available in welding rods $^1/_4$" in diameter and 36 inches long, packed in bundles of 50 lbs. each.

The Iron Oxide Content of Steel in the Open-Hearth Furnace

During the past three years, numerous writers and investigators have attempted to estimate the amount of iron oxide in open-hearth steel by calculation and by analysis. Experimental work conducted by the members of the Metallurgical Section of the Pittsburgh Experiment Station of the United States Bureau of Mines, Department of Commerce, in cooperation with Carnegie Institute of Technology and the Metallurgical Advisory Board, has shown that the amount of iron oxide dissolved in liquid steel in the open hearth is very much higher than had been thought heretofore. Apparently the carbon-iron oxide reaction is slow enough so that the metal is essentially saturated with iron oxide with respect to the slag under a rather wide range of conditions in the open-hearth furnace. This fact changes the concept of methods of working open-hearth heats to a considerable extent in that it emphasizes the importance of chemical composition and physical properties of the slag and the necessity for an even more careful study of deoxidizers than has been carried out up to the present time.

Abstracts of Current Metallurgical Literature

In this section, abstracts of metallurgical articles in various publications will appear. These abstracts are not critical, but merely review developments as they are recorded. Every effort will be made to report on all articles as soon as possible.

Many laboratories do (and more laboratories would if they appreciated its value) adopt the policy of clipping, pasting on cards and filing abstract literature. In order to help those who wish to do this, additional copies of METALS & ALLOYS *will be sent to any subscriber for $2.00 per copy per year extra. The time required for clipping, pasting and filing is so much less than the time needed to transcribe abstracts that a distinct saving can be made by ordering extra copies.*

GENERAL

New Developments in Metals and Alloys. O. W. Ellis. *Canadian Chemistry & Metallurgy*, August 1929, pages 26(223)–30(227).

A paper read before the Engineering Society of Babcock-Wilcock & Goldie-McCulloch, Ltd., at Galt, Ont. June 7, 1929. A brief discussion of heat-treatments accorded aluminum-copper and other non-ferrous alloys. Zinc-aluminum, silicon-aluminum, and some other copper alloys are receiving consideration. Among the latter are copper-cadmium, copper-silicon, silver solders and some recent nickel alloys. An alloy containing 70% Ni, 19.5% Co, 7.4% Fe and 2.8% Ti is being used as a core for oxide-coated, thermionic cathodes, replacing platinum. This alloy, with the Ni–Co content ranging between 80 and 95%, has a very high electrical resistivity, and a great mechanical strength well retained at elevated temperatures. "Permalloy" (Ni 78.23%, Fe 21.35%, Co 0.37%, Cu 0.10% and the remainder C, Si, Mn, S and P) has much greater magnetic susceptibility than iron. Aluminum, chromium and manganese exert a great influence in modifying the manner of nitridation. Two types of alloys have been developed—nitralloy (a chromium-aluminum steel), and a molybdenum-aluminum composition. The nitriding is conducted in an atmosphere of ammonia at temperatures of 510–570° C. Higher temperatures are undesirable. WHB

Some Methods of Research in Physical Metallurgy. Walter Rosenhain. Paper before Institute of Metals, September 1929, 36 pages.

The author outlines the methods which have been developed in recent years mainly in the Metallurgy Department of the National Physical Laboratory for the study of metals, especially in connection with the determination of equilibrium diagrams. The methods of determining and recording thermal curves, resistivity-temperature and dilation-temperature curves are discussed in detail, and a brief account is given of a novel form of electrical dilatometer, making use of measurements of the capacity of a small condenser which is varied by the dilatation of the specimen. The measurement of this capacity is made by means of oscillatory circuits utilizing thermionic valves and the resulting graph is plotted by means of an electrical "thread recorder." Reference is also made to the development of optical pyrometry, and a novel method of securing black body conditions, by sighting upon the interior of a gas bubble blown in a mass of molten metal is described. The applications of the study of structure by means of a microscope and of crystal lattices by means of the X-ray spectrometer are discussed in regard to their bearing upon the equilibrium diagram. Finally, stress is laid upon the importance of securing accurately known composition and the highest possible degree of purity in the metals and alloys used for investigations of this kind. The development of special refractories for the production of metals of high purity is briefly referred to. AEH

Locomotive Forgings. Lawford H. Fry. Paper presented at the Eleventh Annual Convention, American Society for Steel Treating, Cleveland, Tuesday, September 10, 1929.

The production of locomotive forgings which will give good results in service necessitates the employment of correct methods from the melting of steel to the finished forging. The various steel melting processes are discussed and compared. The importance of ingot structure is considered. The forging process is described and the resulting structures of steel forgings illustrated by photomicrographs. The author enumerates the various types of forging steels. The necessity of heat treatment is pointed out and a discussion of the physical properties which may be expected of forging steels. ESC

The Non-Ferrous Metals from a World Point of View. Frank H. Probert. *Engineering & Mining Journal*, Nov. 9, 1929, pages 726–731.

A paper read before the World Engineering Congress at Tokio, Japan. A review showing the necessity of world trade, the industries consuming non-ferrous metals, and pointing out how scientific research and improved practice extend life of mines. Economic aspects of the mining and metallurgy of copper, lead and zinc are briefly reviewed. WHB

Steel's Growing Service to Civilization. E. F. Kenney. *Advance Paper, American Iron & Steel Institute*, Oct. 1929, 15 pages.

Interesting philosophical summary of dependence of civilization on steel. Wheels and rails, locomotives, bridges, elevators, elevated and subway lines, steamships, aircraft motors, automobiles and in general all transportation, are primarily due to steel. Pipe line transportation of water gas, and oil; tools for the manufacture of other metallic and of non-metallic products; containers for food products, sky scrapers, reinforced concrete roads, all depend on steel. Better rails, more corrosion resistant alloys, to stand high temperatures and pressures for high power turbines and for oil-cracking, are problems now calling for solution, on which progress is being made. Scientific inquiry will solve the problems and if the demand is sufficiently urgent, the needed articles will ultimately be forthcoming. In discussion C. P. Perin pointed out that if the present rate of consumption of steel in the United States, 1000 pounds per person per year were extended all over the world the known reserves of ore would be very promptly exhausted. As it is, by 2000 A. D. benefication of low grade ores will be required. Twenty million tons of steel are lost annually by corrosion and there is need for cheaper chromium to allow use of corrosion resistant steels on a tonnage scale. If the Cr content of the Cuban Mayari ores could be economically separated so as to be useful for high-Cr steels, quite an addition to the world's useful stock of Cr might be made. HWG

Possibilities of Revival of Non-Ferrous Metallurgy in Great Britain. (Die Möglichkeiten einer Wiederbelebung der Nichteisenmetallurgie in Gross-Britannien.) W. Cullen. *Metallwirtschaft*, Sept. 6, 1929, pages 883–886.

Paper presented at the Institution of Mining and Metallurgy by its president. EF

The Organization of English Non-Ferrous Industry. (Die Organisation der englischen Nichteisenmetallindustrie.) L. P. Sidney. *Metallwirtschaft*, Sept. 6, 1929, pages 886–888.

Considers producers of non-ferrous metals, semi-finished material industry, London metal market and technical and scientific institutions. EF

Engineering of Non-Ferrous Metals. John R. Townsend. *Iron Age*, Aug. 22, 1929, pages 457–458.

Describes recent developments in mechanical arts which have drawn attention to defects in some old materials and advantages of some more recently developed. Essential requirements of construction materials are: strength, hardness, toughness and elastic properties. Season cracking of sound parts made of some brasses, bronzes or nickel silver is due to a combination of high internal stress and corrosion. Nickel, copper, monel metal and everdur are entirely free from this trouble. Economic factors govern use of special alloys. Rigid specifications necessary for mass production. VSP

Centrifugally Cast Pipes. (Schleudergussröhren der von Roll'schen Eisenwerke.) M. von Anacker & M. Ros. *Stahl und Eisen*, Sept. 19, 1929, page 1380.

Report No. 12 of the Swiss Society for Testing Materials. The authors describe the manufacture, properties and testing of centrifugally cast pipes in different countries. The results are compared with those obtained with the usual sand-cast pipes. The improved properties of centrifugally cast pipes are revealed in a convincing manner. GN

PROPERTIES OF METALS

High-Temperature Practice and New Fluorides. Tests and Demonstrations. (Hochtemperaturtechnik und neue Fluoride. Vorführungen und Versuche.) O. Ruff. *Zeitschrift für angewandte Chemie*, August 3, 1929, pages 807-810.

Paper read at the Convention of the Institute of German Chemists in Breslau, 1929. The vapor pressure curves of Fe, Ni and Co have been determined at high temperatures; the apparatus and tests are described, results given in diagrammatic form. Some fluorides of the rare metals have been produced and investigated. HA

On the Density of Molten Metals and Alloys. Y. Matuyama. *Science Reports, Tohoku Imperial University*, May 1929, pages 19–46.

The investigation covers the determination of the density of five pure metals: Sn, Cd, Bi, Pb, Zn, seven binary alloys: Sn-Cd, Sn-Bi, Bi-Pb, Sn-Zn, Bi-Cd, Cd-Pb, Cd-Zn and six ternary alloys: Sn-Bi-Cd, Bi-Cd-Pb, Sn-Bi-Pb, Sn-Cd-Pb, Sn-Cd-Zn, Cd-Pb-Zn. A special method was used in the test. GN

The Production and Uses of Beryllium. Kurt Illig. *Electrician*, Oct 11, 1929, pages 426–427.

The properties of beryllium and means of obtaining it are briefly outlined. Results of commercial investigations by the Siemens-Halske, A. G are indicated. Electrolysis of the double fluorides give best results. Beryllium of 99.9% purity has been obtained, with iron the main impurity. Pure beryllium is extremely hard and brittle, scratches glass and can be neither rolled nor drawn, because of its coarse crystal structure. The addition of 2–2.5% of beryllium to copper or nickel produces alloys possessing properties like those of bronzes. Beryllium-aluminum alloys show properties like those of duralumin and silimin, though slightly favoring the beryllium-aluminum. Economic competition is impossible with silicon, magesium, and copper in making alloys with aluminum. Beryllium alloys are improved by heat treatment. Six to seven percent is the limit for beryllium in copper or nickel alloys. In general, the quenched alloys are very elastic and strong. Heat treatment increases the elastic limit and the yield point by about 800%, while the tensile strength and the transverse bending strength increase about 3–4 fold. The ductility decreases proportionally with strength. These alloys may be rolled, drawn and pressed. Beryllium improves the electrical conductivity of these alloys. Beryllium may be used as a deoxidizer in copper castings. WHB

The Effect of Iron on the Magnetic Susceptibility of Aluminum. R. B. Mason. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 211–218.

The magnetic properties of the purest aluminum available to-day with 99.97% Al are investigated and compared with commercial grades of Al and various alloys. It is found that pure Al is paramagnetic, which property is slightly increased up to 8% of Fe which occurs in an intermetallic compound. Etching results in a marked increase of magnetic susceptibility due to the liberation of Fe in the surface film. The method described is useful in the approximate estimation of the Fe content of Al. EF

On the Road to Pure Iron and Some of Its Indicated Properties. T. D. Yensen. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 88–95.

The purity of iron has been gradually increased up to 99.95%. The remaining 0.05% consists partly of substitution elements, such as Al, Si, etc., and partly of elements, such as C, P, etc. The latter have a greater effect on the physical properties and are very difficult to remove simultaneously. But samples have been secured with greatly improved magnetic properties, indicating that pure Fe may have a hysteresis loss approaching zero and exceedingly high permeability. EF

The Fatigue of Metals—A Review of Progress from 1920 to 1929. H. F Moore. *Advance Paper, American Iron & Steel Institute*, Oct. 1929. 24 pages.

Outstanding advances in knowledge of the fatigue, or progressive failure of metals in the last ten years, is reviewed. Establishment of the fact that for ferrous metals there is a real endurance limit; understanding of the dangers of corrosion-fatigue and some progress in combating it, a fairly well developed theory of fatigue failure based on formation of sub-microscopic cracks at minute local points, and better understanding, due to fatigue tests, of the fatal effect of surface notches, are some of the outstanding points. The paper is a very clear and concise statement of the present status of knowledge in the field. The electrical resistance method is considered to hold promise as an accelerated test, but Prof. Moore urges that other laboratories check the method. In discussion J. A. Capp stated that not the least valuable part of the accumulated knowledge was the theory of localized failure which helps the designer to realize that endurance data are needed for design of repeatedly stressed parts, while static data are adequate for design for static stresses where it is the average or statistical strength, not the local strength that counts. F. N. Speller emphasized that corrosion-fatigue is due to surface notches and mentioned the effect of inclusions as internal notches. H. W. Gillett referred to the testing of large sections and the evidence that internal notches, shatter cracks, etc., were as dangerous as surface notches, as important features of present knowledge. HWG

The Arc Spectrum of Nickel. Henry Norris Russel. *Physical Review*, Sept. 15, 1929, pages 821–857.

Almost all the known lines (1071) of NiI have been classified. There are included in the classification 66 lines from the solar spectrum which have not been found in the laboratory. The spectrum in spite of its apparent complexity, is admirably regular. Every observed term fits without constraint into the scheme predicted by Hund's theory. A few of the predicted terms have not been found, but in all cases their combinations, configurations and identified lines are tabulated.

The Technical Importance of Lithium. (Die technische Bedeutung des Lithiums.) E. Thieler. *Metallwirtschaft*, Aug. 23, 1929, page 823.

In the introduction, the paper covers the chemical and physical properties, occurrence and production of this lightest of all substances, the author outlines its application in glass and ceramic industry for pharmaceutical and solder purposes, storage batteries and last but not least in bearing metals, widely used in Germany due to the shortage of Sn during the war. The Pb-Ca-Li alloy for instance is used by the Deutsche Reichsbahn. The second metallurgical importance is as an alloying element in light metals as Scleron, replacing Mg which must be bought abroad. A quite recent application as a strong deoxidizer of Cu exhibited superiority to P formerly used. The price is about $42 per kg. The author mentions in conclusion experiments in the U. S. A. to add Li to copper bars destined for the manufacture of rolled sheets to improve surface conditions. EF

The Correlation of Fatigue and Overstress. J. H. Smith, C. A. Connor & F. H. Armstrong. *Paper before Iron and Steel Institute*, Sept. 1929, 29 pages.

The authors have examined the phenomenon of fatigue in metals. They used the "strain" method, and are agreed that yield ranges are identical with limiting fatigue ranges. Their conclusions are as follows: (1) After a material has been overstressed by a symmetrical range of periodic stress, its stress strain loops below the yield are closed and symmetrical. (2) After overstress by an unsymmetrical range of stress, the stress-strain loops of a material are closed and unsymmetrical. (3) Symmetrical overstress increases the yield ranges of a material. (4) Unsymmetrical overstress increases the yield ranges of a material. (5) It is possible to obtain closed stress strain loops with fatigued material. (6) Fatigued material which has been stressed with practically the maximum value of stress, and is nominally overstressed with respect to the corresponding normal material, is in a cyclic state, and yields at equal values of mean stress both in tension and in compression. (7) Fatigued material, overstressed with respect to other fatigued material, has greater values of yield ranges, the yield range curve in the former case falling well outside that in the latter case. (8) Fatigue increases the yield ranges of a material. (9) Fatigue and overstress have similar actions upon the yield ranges of a normal steel. AEH

PROPERTIES OF NON-FERROUS ALLOYS

Service Characteristics of Light Alloys. E. H. Dix, Jr. *American Machinist*, September 12, 1929, pages 441–444.

Heat-treated aluminum alloys possess mechanical properties comparable with those of structural steel. Annealing lowers the tensile strength of magnesium alloys several thousand pounds per square inch and raises the elongation slightly. Aluminum copper alloys slowly cooled are in soft annealed condition, but if quenched rapidly, they are in hard and strong heat-treated condition. The addition of all alloys except about 1.25% manganese reduces corrosion resistance properties of aluminum. Differences in aging vary the tensile strength and susceptibility to corrosion of the various alloys. "Alclad" possesses excellent corrosion resistance properties and good mechanical properties. Its aluminum alloy core is covered with thin layers of pure aluminum. KF

Continuation of the Study of Plasticity. (Suite a l'étude de la viscosité.) J. Cournod. *Revue de Metallurgie*, June 1929, pages 326–328.

Continuation of the previous studies (Jean Cournod & K. Sosagawa, *Revue de Metallurgie*, December 1925, page 735; Jean Cournod & R. Pages, *Revue de Metallurgie*, December 1926, page 701; Jean Cournod & M. Soares Silva, *Revue de Metallurgie*, February 1928, page 82). Determined by the method described in the previous papers, the plasticity of aluminum and duralumin at different temperatures and loads increases with the diminution of the cross-section. The rise of the temperature lessens the effect of size. Elastic limit becomes higher with larger sections. Permissible limits are given. JDG

The Creep of 80:20 Nickel-Chromium Alloy at High Temperatures. A. Glynne Lobley & C. L. Betts. Paper before Institute of Metals, September 1929, 20 pages.

The rapidly increasing use of nickel-chromium alloys in electric furnaces for resistors and constructional purposes has necessitated a fuller knowledge of the mechanical properties of these alloys at high temperatures. The authors subjected the wires 0.018 in., 0.0625 in. and 0.25 in. in diameter to tensile stresses of 50, 100, 200 and 400 lb./in.^{2} at temperatures of 700, 800, 900 and 1000° C. for a period of approximately 4000 hours and made accurate measurements daily of the movements. At the higher temperature there was no evidence of creep stress limit. The rate of flow was found to be dependent on the diameter of the wire as well as on the other factors. Below 900° C. and above 700° C. no evidence of creep stress limit in the case of fine wires was found. The evidence regarding the thicker wires was not conclusive, but there appears to be a kind of creep stress limit between 200 and 400 lb./in.^{2} In the case of wires or rods thicker than 0.06 in. abridged graphs and graphs are used to show the progress of the experiments and also show the relationship between the various conditions of temperature, stress and diameter. AEH

The Hall Effect, Electrical Conductivity, and Thermoelectric Power of the Copper-Tin Series of Alloys. Emlyn Stephens. *London, Edinburgh & Dublin Philosophical Magazine & Journal of Science*, September 1929, pages 273–289.

Theoretical discussion with diagrams and tables of the experiments conducted to determine the electrical resistivity, temperature coefficient of resistance, thermoelectric power and Hall effect of the copper-tin series of alloys. The alloys were chill cast in an iron mold in the form of plates and the electrical resistivity at 0° C. was determined. Resistivity was redetermined after annealing at suitable temperature, and the annealing process was continued until no further variation was shown. Although the Hall effect is negative for both copper and tin, it is positive for alloys ranging between 74% Cu, 26% Sn and 4% Cu, 96% Sn. Cu_3Sn has a maximum positive Hall coefficient of 0.000935. The effect of annealing on resistivity of alloys depends on their composition. KF

Examination of Tin Foil for Packing Cheese. (Untersuchung von Zinnfolie zur Verpackung von Käse. Rindenloser Käse.) Dr. Elten. *Chemiker Zeitung*, July 27, 1929, page 586.

Tin foil containing 0.1–0.2% Pb, 2–4% Sb exhibited corrosion attack by acids of the cheese. Diffusion of 2.3% Sn into the interior parts of the food took place. The undissolved Sb remained as black dots on the foil. EF

Partial Molal Heat Capacities and Relative Partial Molal Heat Functions in Solutions of Molten Metals. Albert N. Guthrie & Earl E. Libman. *Journal American Chemical Society*, June 1929, pages 1711–1715.

Wüst and Durrer have measured the specific heats of Pb–Sb and Bi–Cd solutions at different concentrations, and the heats absorbed per gram in going from the pure solid components to the liquid solution at the eutectic temperature for different concentrations. From these data the authors have calculated the relative partial molal heat functions of the components of the systems Pb–Sb and Bi–Cd for the eutectic temperatures, the partial molal heat capacities of Pb and Sb at 700° C., and of Bi and Cd at 300 and 1000° C. MEH

PROPERTIES OF FERROUS ALLOYS

High-Strength Cast Iron. E. J. Lowry. *American Machinist*, September 5, 1929, pages 412–413.

Abstract of paper presented at A. S. S. T. meetings in Cleveland, September 9–13. Discusses necessity of classification of varying types of cast iron according to their merits to enable engineers to distinguish among them. KF

Steam Lines of the Power Station at Issy-les-Moulineaux and the Characteristics of Steels at Elevated Temperatures. (La tuyauterie de la Centrale d'Issy-les-Moulineaux et les caracteristiques a chaud des aciers.) G. Dessus. *Revue de Metallurgie*, August 1929, pages 444–446.

A general discussion of the requirements to be met by steam pipes and of some methods for testing them. JDG

Characteristics of Mayari Iron. *American Machinist*, September 12, 1929, page 453.

General discussion of Mayari iron and silvery Mayari iron. KF

On the Specific Heat of Pure Iron at High Temperatures. S. Umino. *Science Reports of Tohoku Imperial University*, May 1929, pages 91–107.

The specific heat of pure electrolytic iron was measured between 680 and 1560° C. The data on the true and mean specific heat, the heat of the iron transformations and that of fusion are given. The data is partly taken from that of the latest German investigation by P. Oberhoffer and W. Grosse. The heat of the A_3 transformation is given as 5.60 cal. per gram, that of the A_4 transformation as 1.86 cal. per gram; heat of fusion 65.65 cal. per gram. GN

New Investigation on the Physical Properties of Iron Alloys. (Neuere Untersuchungen über die physikalischen eigenschaften der Eisenlegierungen.) A. Schulze. *Giessereizeitung*, July 15, 1929, pages 389–398; August 1, 1929, pages 428–434.

The paper gives the results of the last ten years' investigations on the physical properties of a large number of iron alloys. The electric and magnetic properties, the density and the thermic dilatation are expecially dealt with, and the results of the different investigators are given in tables and diagrams. The following systems are covered: Fe–C, Fe–Ni, Fe–Al, Fe–Mu, Fe–Co, Fe–Cr and non-rusting steels. GN

Properties of Materials at High Temperatures. 4.—The Strength at Elevated Temperatures of Low Carbon Steels for Boiler Construction. *Special Report* No. 14. *Engineering Research. Department of Scientific and Industrial Research*, 42 pages.

The work described in the report was carried out at the National Physical Laboratory for the Committee appointed by the Department of Scientific and Industrial Research to direct researches on the behavior of materials at high temperatures. Owing to the rapid development of high pressure boilers for marine and land use (and the increasing danger of accident arising therefrom), the Board of Trade required information on the tensile and creep properties of boiler materials, particularly those used for boiler and superheater tubes. The report gives the results of tests carried out up to a temperature of 650° C., and also includes information on the form of the extension-time curves (under prolonged loading), a comparison of the values of the initial limits of proportionality with estimated limited creep stresses, and observations on scaling or oxidation and intercrystalline cracking. The results of the investigation are of special importance to manufacturers of boiler plants in which high superheat temperatures are to be used. The limits within which ordinary carbon steels can be used with confidence are indicated with a fair degree of definiteness, and the information gives a valuable lead to those interested in the improvement in efficiency of steam plants. The information contained in the report is also of great value to anyone concerned with apparatus or machines in which low carbon steels are subjected to high temperatures.

Properties of Materials at High Temperatures. 5.—The "Creep Strength" of a "High Nickel-High Chromium Steel," between 600 and 800° C. *Special Report No. 15. Engineering Research. Department of Scientific and Industrial Research.*

This report describes work carried out at the National Physical Laboratory with the object of obtaining data on the creep properties of a "high nickel-high chromium steel" at temperatures between 600 and 800° C. as an indication of the probable behavior of the same steel when used in the form of exhaust turbine wheels for supercharger units. The results of short time tensile tests and creep tests are expressed in tables and in graphical form.

The Relation Between Different Hardness Values of Unquenched Plain Carbon Steels. (Die Beziehungen zwischen verschiedenen Härteziffern bei ungehärteten Kohlenstoffstählen.) A. Wallichs & H. Schallbroch. *Stahl und Eisen*, Sept. 12, 1929, page 1349

Paper appearing in *Maschinenbau*, Aug. 1929, pages 69–74. The comparison values of the various hardness tests were examined with carbon steels from 0.1 to 1% carbon. In the table below: H_n = Brinell hardness S = Shorehardness, R_B and R_c = Rockwell hardness, Z_S = Herbert hardness with steel ball, Z_D = Herbert hardness with diamond ball, J_S and J_D corresponding induced hardness. For a Brinell hardness between 80 and 300 units is:

$$H_n = -40 + 8.4S - 0.03\,S^2 \qquad = \frac{7900}{130 - R_B}$$

$$= \frac{1930000}{(107 - R_c)^2} \qquad = 24 + 0.305\,Z_S^2$$

$$= 41 - 3.9\,Z_D + 0.78\,Z_D^2 \qquad = 239 - 17\,J_S + 0.52\,J_S^2$$

$$= 27 - 4.6\,J_D + J_D^2$$

Alloyed structural and tool steels were investigated. GN

Bearing Metal "Thermit." (Das Universal-Lagermetal Marke "Thermit.") *Werkstattstechnik.*, Sept. 15, 1929, pages 543–545.

Thermit is a nickel bearing metal, with a relatively high melting point (final freezing 245° C.), a small shrinkage 0.55%, a slow change of hardness with rising temperature and favorable qualities of friction. Thermit is especially suited for machines, the bearings of which are exposed to high temperatures. GN

Physical Properties of Chromium and Tungsten Steels. (Physikalische Eigenschaften von reinen Chrom und Wolframstählen.) F. Stäblein. *Archiv für Eisenhüttenwesen*, Oct. 1929, pages 301–305.

The physical properties of pure iron-chromium and iron-tungsten alloys with as high as 24% Cr and 28% W were determined. The density and magnetic properties change in agreement with the law of ideal solutions. The magnetic saturation shows a maximum in the case of the tungsten alloys, which is caused by the intermetallic compound. It has so far not been possible to definitely determine if this compound is Fe_3W_2, FeW or Fe_2W. The dilatometric curves of iron-chromium alloys are of considerable interest. In alloys containing 0.03% C. critical points could be determined up to 16.8% Cr, while in an alloy with 0.01% C no critical points were found above 12.62% Cr. As the only variable in the two alloys was the carbon, this no doubt was the cause. CK

On the Intensity of Magnetization of Iron-Nickel Cobalt-Alloys. Hakar Masumoto. *Science Reports of Tohoku Imperial University*, June 1929, pages 195–229.

Paper at the spring meeting of the Physico-Mathematical Society of Japan, April 3, 1928. The relation between the magnetization and the equilibrium diagrams of the iron-nickel-cobalt alloys was investigated. The intensity of magnetization of the mentioned alloys was measured by the ballistic method. The irreversible iron-nickel alloys are much less magnetizable than the reversible ones. The magnetization-concentration curve shows a minimum at 30% nickel and two maxima at 5 and 45% nickel. The small intensity of magnetization of the 70 iron-30 nickel alloy increases with cobalt added. Iron-cobalt alloys, containing 70% to 95% of cobalt, have a very high permeability in weak fields. The α-solid solution above 95% Co, having a close-packed hexagonal lattice, is not easily magnetizable. The maximum permeability is at about 35% Co. The α-phase of nickel-cobalt alloys up to 70% Co has a high permeability, above 70% Co the magnetization is difficult. The permeability of incoercible ternary alloys of iron-nickel-cobalt is small. GN

Iron-Silicon-Carbon-Alloys. Constitutional Diagrams and Magnetic Properties. T. D. Yensen. Paper before Institute of Metals, September 1929, 17 pages.

Part work in connection with the magnetic properties and metallography of iron-silicon-carbon alloys is reviewed and briefly discussed. The author advances the hypothesis that α-iron, even in the absence of silicon, can exist at all temperatures below the freezing point and that the α-modification is due to the presence of interstitial impurities, including carbon. Hence α-iron is not an inherent characteristic of Fe. Constitutional diagrams are given for Fe–C, Fe–Si–C, (Fe + 2% Si)–C, and (Fe + 4% Si)–C. These are used to explain the various forms in which carbon occurs in Fe–Si–C alloys and these forms in turn serve to explain the magnetic properties of the alloys and the results of the various heat treatments. The author suggests that magnetic testing is much more sensitive in detecting small amounts of certain impurities such as carbon, and the form in which they exist than either metallographic or ordinary chemical analysis and anticipates that magnetic analysis will eventually become an important branch of metallurgy. AEH

High-Elastic-Limit Steel. History & Development. *Iron & Coal Trades Review*, August 9, 1929, page 193.

A review of a paper read before the West of Scotland Iron & Steel Institute by F. G. Martin. The original paper emphasizes the difference between the terms elastic limit and "yield point." The latter is shown not to be a definite function of the maximum stress. A high elastic-limit mild steel was developed which had the following mechanical properties: true elastic limit (not yield point), 15 tons/in.^{2}, maximum stress 29–34 tons/ in.^{2} elongation on 8 in. (for plates less than 0.375 in. thick) not more than 17% for plates greater than 0.375 in. thickness not less than 21%. Bend test: A test piece at least 2 in. wide should bend through 180°. These tests apply for longitudinal and for transverse test pieces. The true elastic limit is closely wrapped up with crystal size, and with uniformity of structure. Methods of testing are reviewed and the behavior of high-elastic limit mild steel in ship construction discussed. In S. S. "Prometheus" 53% of the steel of construction is high-elastic-limit steel, with reduction in scantlings for varying thicknesses was 10–15% and the actual amount of weight saved on the ship was about 300 tons. Four years' service had yielded only satisfactory results and the holds made of this steel require much less painting than those made of ordinary mild steel. WHB

A Study of the Physical Properties of Hadfield Steel in Relation to the Microstructure and Thermal Treatment. (L'acier Hadfield, étude des ses proprietes physiques en correlation avec la microstructure et le traitement thermique.) V. N. Svetchnikoff. Translated by L. Dlougatch. *Revue de Metallurgie*, August 1929, pages 401–408.

A study of metallographic features, impact characteristics and resistance to abrasion of a steel: C 1.23%, Mn 12.67%, Si 8.35%, P. 10%. Abrasion figures were obtained by holding standard specimens on a wet, rotating emery wheel under standard conditions and determining the loss by weighing. A series of heat treatments was conducted on forged specimens. Their impact values were determined. The specimens were notched with a rotating steel disk fed with emery powder in suspension. The apex of the notch was finished with wire of proper diameter fed with emery powder. Maximum impact values did not coincide with temperatures resulting in uniform and fine grain, but needed higher temperatures. The results of micrographical examination suggest that the changes in physical properties were connected here with the abnormally high P content. This steel had considerably better abrasion resisting properties than any other metal tried and had a much higher impact value. JDG

Endurance Bending Tests of Steels. (Dauerbiegeversuche mit Stählen.) E. Hondremont & R. Mailander *Krupp'sche Monatshefte*, April, May 1929, pages 39–49.

The experiments give the results of 170 groups of tests with different steels, generally used in forged and rolled condition. The results can be summarized as follows:

(1) The relation between alternating strength (S), tensile strength (σ_B) and yield point (σ_s) were examined. It is $S = c \times \sigma_B(\sigma_s)$. The factor c was determined. The average value of the results were obtained by the equations $S = 0.50 \times \sigma_B$ and $S = 0.285\ (\sigma_B + \sigma_s)$. Very hard, and very soft steel strengths can be derived from the last equation but the equation S—$5 = 9.245 \times (\sigma_s + \sigma_B)$ is satisfactory for all steels. The relation $\sigma_s : \sigma_B$ has an influence on the alternating strength. Higher values of ($\sigma_s : \sigma_B$) with unchanged σ_B give higher values of $\sigma_s : \sigma_B$.

(2) The influence of composition was investigated with carbon steels, silicon steels, manganese steels, nickel steels, chromium steels, chromium-nickel steels and austenitic steels. The value c decreases with increasing carbon content. Silicon gives normal values, only silicon structural steels show increased c. The value c for nickel steel is close to the upper limit. Chromium steels with a tensile strength from 78,000 to 121,000 lb./in.^{2} correspond to the normal value c. For chromium steels above 128,000 lb./in.^{2} tensile strength c is below the average value. Chromium-manganese-silicon spring steels have also a normal value of c. For austenitic steels the value c is only applicable when the tensile strength corresponds to the Brinell hardness.

(3) The influence of structure was investigated. The alternating strength decreases in soft steels with increasing grain size. Improved heat-treatment improves the value of c. c decreases with cold-working.

(4) The influence of the condition of the surface was examined with 26 steels. The importance of a careful treatment of hard structural steels can be seen from the table:

Steel	Tensile Strength Lb./In.^{2}	Alternating Strength Lb./In.^{2} Polished	Ground	Notched
1	56,900	28,450	26,300	19,200
2	184,900	92,450	78,200	37,700

GN

Investigation on Copper Steel with High Carbon Content. Stogov & Mesikin. *Trans. Inst. of Metals*, No. 1, Moscow, 1928.

There were investigated high carbon copper steels containing 0.69–1.22% carbon and 1.19–5.07% copper. Melts were made in crucibles. Ingots were forged into square bars having 16 mm. × 16 mm. cross section, which were then annealed. For this purpose of comparison the parallel tests with the plain carbon steel containing 0.66–1.06% carbon were carried out. The following items were determined by the authors: (*a*) Critical points which were determined by means of the differential and dilatometer methods. (*b*) Electroconductivity at room temperature. (*c*) Microstructure of the annealed, quenched and of the drawn specimens. (*d*) Magnetic properties of the quenched and of the annealed specimens. (*e*) Mechanical properties of specimens subjected to the different heat treatments. Conclusions drawn by the authors were as follows: (1) The copper addition lowered somewhat (up to 640° C.) the critical point Ar_1 and caused a considerable temperature hysteresis (Ac_1–Ar_1) which in some cases reached 90° C. This phenomenon, however, had no effect on the microstructures observed. (2) There was no increase in depth of the quenching with the copper addition. (3) Copper increased the coercive force (Hc) of steel up to 75 gauss, thus increasing the product Br × Hc up to not 1× 10^3. The residual magnetism (Br) of the copper steel was found to be not less than that of the plain carbon steel. (4) The increase mentioned above in the coercive force and in product Br × Hc seemed to be accompanied by an increase of the internal stresses and partly of the hardness. (5) A decrease in the magnetic flux in the copper steel with aging was somewhat smaller than that in the plain carbon steel. It was, however, larger than the corresponding decrease observed in the case of chromium-tungsten steel. (6) The proportional limit, tensile strength and hardness were increased with a copper addition, whereas elongation, reduction of the cross sectional area and the resistance to impact were decreased. (7) The copper steel which was tempered after quenching gave very high proportional limit and tensile strength showing at the same time good elongation and reduction of the cross sectional area. AK

CORROSION, EROSION, OXIDATION, PASSIVITY AND PROTECTION OF METALS AND ALLOYS

Rust-Proofing Steel and Aluminum for Aircraft Parts. *Iron Age*, August 15, 1929, page 409.

Discusses the protection of metal parts used in construction of British airship R-101. Anodic oxidation process is used for the protection of aluminum and its alloys. Die-cast aluminum silicon alloy is corrosion resistant. Duralumin parts are coated with a film of oxide and lanoline. Steel members, outside of stainless steel, are sherardized. VSP

A Study of Burning and Overheating of Steel. Part II. W. E. Jominy. *Transactions American Society of Steel Treating*, September 1929, pages 372–392.

This paper is the second of a series of articles on the subject. A study of the limiting temperatures of forging after heating in various atmospheres. The experiments were made on a series of plain carbon and alloy steels. The results are summarized in a table showing the temperatures at which the various steels investigated will burn if forged immediately after heated in a direct-fired gas furnace when using an excess of air and gas. ESC

Idiomorphic Crystals of Cuprous Oxide in Copper. Clement Blazey. Paper before Institute of Metals, September 1929, 4 pages.

Cuprous oxide occurs in nature in crystals, commonly octahedral, belonging to the isometric system. In copper and copper alloys it occurs in masses, or eutectic particles, rounded in shape. The occurrence of crystallized cuprous oxide has been observed in a sample of copper which was unintentionally heated for nearly a year beneath a furnace floor. The form and character of these idiomorphic crystals are described. AEH

Heat Resisting Steels. (Warmfeste Stahle.) E. Houdremont & V. Ehnicke. *Krupp'sche Monatshefte*, July 1929, pages 79–94; also *Archiv für Eisenhüttenwessen*, July 1929, pages 49–60.

The means for the determination of the tensile properties at higher temperatures are not yet sufficiently exact to obtain reliable figures. The consequence of the impossibility to give exact data for the creep limit, technical comparison tests and tensile tests with a certain experiment time from 15 to 20 minutes are valuable to judge the properties of a material at higher temperatures. The properties of steels at raised temperature are dealt with in two groups: (1) below 650° C. (2) above 650° C. (1) For steels with improved heat-resisting properties up to 650° C., those alloying elements are especially qualified which already increase the properties at room temperature. Small quantities of molybdenum or vanadium have a most favorable influence on the hot tensile strength. The improvement of the hot tensile strength of higher alloyed steels is in connection with the raising of the temperature of recrystallization. Cr, W, Mo, V must be mentioned in this group as alloying elements. The correct heat-treatment is most important factor. (2) For steels to have improved hot tensile strength above 650° C. the following viewpoints are mentioned. Those elements should be alloyed which do not decrease the melting point very much and which form no eutectics. Alloys with a high melting point show a high temperature and a low velocity of recrystallization. These are favorable properties for heat-resisting steels. The consequence of the higher resistance to deformation and the smaller inclination of α-iron to recrystallize, steels with austenitic structure will become important for the application at temperatures above 650°. Some of the results are given in the tables below.

1. Influence of the Composition on the Hot Tensile Strength of High Chromium and Chromium-Tungsten Steels.

C	Si	Mn	Ni	Cr	W	V	Kind of Steel	Hot Tensile Strength at 800° C. Lb./In.^{2}
			Percent					
1.50	..	..	...	13.50	..	..	Base α-Iron	13,500
1.40	..	..	...	11.20	2.00	0.80		11,500
0.55	3.00	..	...	11.00	..	..		7,800
0.55	3.00	..	...	11.00	1.50	..		10,650
0.60	..	..	13.80	14.80	2.00	..	Base γ-Iron	35,500
0.60	..	4.80	...	13.30	5.00	..		32,850
0.70	..	4.70	...	14.50	..	..		31,850

2. Influence of Chromium and Tungsten on the Hot Tensile Strength of Austenitic Steels.

C	Mn	Ni	Cr	W	Yield Point at 800° C. Lb./In.^{2}	Tensile Strength at 800° C. Lb./In.^{2}
0.60	4.50	14.90	...	...	11,400	19,900
0.55	4.60	12.90	3.00	...	16,100	29,300
0.70	4.70	...	14.50	...	24,200	31,850
0.55	4.50	14.60	...	4.80	23,050	33,550
0.56	4.50	14.40	...	9.90	25,750	34,700
0.30	..	11.00	4.00	17.00	31,300	33,700

Artificial Corrosion of Japanese Special Alloys (Künstliche Korrosion von japanischen speziallegierungen.) D. Uno. *Korrosion und Metallschutz*, June 1929, pages 121–130; July 1929, pages 147–156.

The present paper read at the session of the Reichsausschuss für Metallkunde, Berlin, 1928, represents a thorough scientific investigation on the color phenomena due to corrosion produced for more than a thousand years on the Japanese special alloys Schakudo (Cu-Au-alloy with a maximum content of 7% Au) and Shibuizi (Cu-Ag alloy with 20–25% Ag). Each alloy was etched by more than 110 different etching reagents, the results of which are collected in tables. Microscopic investigations, reproduced in large numbers in the paper, led to the theory explaining the formation of these violet-blue and yellow-green color appearance at the surface by oxidation and optical interference and by the different attack of a primary solid solution and a eutectic, respectively. In contrast with former investigators, the author lays stress upon the catalytic oxidation due to the Ag atoms in the presence of corrosive reagents. The author furthermore studied the influence of some 16 added elements and the corrosion effect in relation to the heat-treatment and recrystallization. The unexplored ternary diagrams have been investigated by the author who in conclusion states the principles of artificial corrosion. 13 tables, 73 illustrations. EF

On the Composition of Iron Fluoride. (Ueber die Zusammensetzung von Eisenfluorid.) E. Deussen. *Monatshefte für Chemie*, June 1929, pages 107–116.

The author settles the question concerning the composition of iron fluorides. The methods of preparing and determinating both compounds of FeF_3 containing 3 and $4^1/_2$ molecules of water. The attention of the metallurgist is directed to the appendix dealing with the corrosion of Krupp's V2A non-corrosive steel (70% Fe, 23% Cr, 7% Ni) by aqueous hydrofluoric acid (20, 10 and 5% solutions). The experiments proved as a result of the attack of 15–20 minutes that platinum cannot be replaced by the V2A steel in case of hydrofluoric acid. EF

The Open-Air Corrosion of Copper. A Chemical Study of the Surface Patina. W. H. J. Vernon & L. Whitby. Paper before Institute of Metals, September 1929, 15 pages.

The patina on copper after prolonged exposure to the open air has been studied, samples having been taken from copper structures in urban, rural and coastal districts, respectively. Provided the exposure has been sufficiently prolonged, and in the absence of certain prejudicial circumstances, a pleasing green patina characterizes the metal surface in each type of atmosphere. Frequently (in urban districts invariably) the metal passes through a preliminary black stage, the persistence of which is favored by the presence of lead in the metal and by shielding from wind and rain. In general, the green patina consists essentially of basic copper sulphate. An exception to this is the product from a purely marine atmosphere, in which basic copper chloride predominates; where urban and marine conditions coincide, however, then basic sulphate in the product greatly predominates over basic chloride. Contrary to the general belief, basic copper carbonate enters only to a minor extent into the composition of the product, even in rural districts removed from sea and town. Sulphur compounds, derived from products of combustion and disseminated by wind, are the most potent agents in the development of patina. The underlying metal, after long periods of exposure, shows remarkable freedom from pitting. With the exception of lead, which tends to accumulate in the product, the impurities usually present in the metal have no appreciable effect on the composition or appearance of the patina. AEH

Deterioration of Structures in Sea-Water. 9th Interim Report of the Committee of the Institution of Civil Engineers of the Dept. of Scientific & Industrial Research. *Iron & Coal Trades Review*, August 30, 1929, page 300.

The best and poorest metals show greater differences in resistance to sea action in aerated tests than in complete immersion tests where the metals behave much alike. The addition of 0.6–6.2% of copper enhanced the resistance of mild steel 10–30%, and the addition of $3^3/_4$% of nickel to mild steel rendered it appreciably more resistant than the cupriferous steels and 50% more resistant than ordinary mild steel. Cast irons were highly resistant to corrosion in all tests except the fresh-water tests. In the latter test losses were similar. Cold blast metal is slightly inferior to the hot blast. When dissimilar metals were in contact one was preserved at the expense of the other. Results of the aerated test were erratic. In the alternate wet and dry and in the complete immersion tests the chromium and the high-nickel steels were remarkably preserved by contact with mild steel, and the steel was preserved by wrought iron. The values of various paint coatings are indicated. Where preservative coatings were applied best results were obtained with sandblasted plates coated with horizontal retort tar at 80° C. followed by 3 to 4 coats of shellac, varnish and two coats of white-lead paint. Consistently good results appear with plates covered with tar B applied at 80° C. over the mill-scale or 200° C. to cold sandblasted plates. Worst results were obtained by vertical retort tar applied to sandblasted plates at 80°. WHB

The Relative Corrodibilities of Ferrous and Non-Ferrous Metals and Alloys. Part II. J. Newton Friend. Paper before Institute of Metals, September 1929, 4 pages.

Fifty-four bars of ferrous and non-ferrous metals were exposed to air on the roof of the Birmingham Central Technical College for seven years, and an account is given of the 17 non-ferrous bars. The metals examined included tin, lead, nickel, zinc, aluminum and various coppers and brasses. All resisted corrosion much more efficiently than the wrought irons and carbon steels. Aluminum ranked with lead, tin, and stainless steel in offering a very high resistance to corrosion. The influence of arsenic on copper is discussed. AEH

STRUCTURE OF METALS AND ALLOYS

Structure and X-ray Analysis

Radiography as a Tool in the Metal Industry. W. L. Fink & R. S. Archer. *Transactions American Society for Steel Treating*, October 1929, pages 551–599; *American Machinist*, Sept. 5, 1929, pages 409-410.

Includes discussion. Paper presented before the Eleventh Annual Convention of the American Society for Steel Treating, Cleveland, September 11, 1929. Radiography as employed in the regular commercial operations of the Cleveland plants of the United States Aluminum Company. A number of typical examples of applications which have been made of the radiographic method are discussed. The cost of these radiographs is given and the field of profitable application of the method discussed. Brief descriptions of the methods and apparatus are given. A comprehensive bibliography is appended. ESC

Practical Applications of the X-ray in Metal-Working. G. S. Affleck. *Modern Machine Shop*, September 1929, pages 64, 66 and 68.

Article discusses uses of the X-ray for aluminum casting inspection. MBR

Studies on the Crystallization of Gold from the Liquid State. C. O. Bannister. Paper before Institute of Metals, September 1929, 4 pages.

This paper deals with the crystallization of gold from the liquid state and gives different methods of preventing undercooling and "flashing." Formation of straight boundary lines by the interference of radial growth from two, three or four nuclei, as well as the formation of curved boundary lines by retardation of growth from one center are illustrated. AEH

The X-ray Diffracting Power of Copper and Iron for Molybdenum and Copper Radiation. Alice H. Armstrong. *Physical Review*, September 15, 1929, pages 931–936.

Ionization spectrometer measurements were made of the intensity of reflection of the $K\alpha$ doublet of Mo and Cu from copper and iron powders. From the relative intensities of reflection from the different planes of the powdered crystals, the atomic scattering factor values for these reflections were calculated.

A Dilatometric Study of Some Univariant Two-Phase Reactions. Pierre A. Chevenard, Albert M. Portevin & Xavier F. Wache. Paper before Institute of Metals, September, 1929, 29 pages.

The authors have investigated, by means of a dilatometer, the reactions taking place in quenched aluminum-copper and aluminum-silicon alloys, when annealed at various temperatures. The laws of precipitation during constant temperature annealing and the influence of temperature on the speed of precipitation have been studied. A hitherto unknown reaction has been found and partially elucidated. Alloys of iron, nickel and copper have also been investigated by means of the dilatometer, and the boundary of the two-phase field on the iron side of the system has been determined. AEH

X-ray Investigation of Iron and Zinc Alloys. Atomi Ôzawa & Yoshiki Agawa. *Science Reports, Tohoku Imperial University*, June 1929, pages 165–176.

Two intermetallic compounds, Fe_3Zn_{10} and FeZ_7, were found by X-ray examination. Fe_3Zn_{10} is cubic, parameter 8.93 Å, 52 atoms in the unit cube. $FeZn_7$ has a hexagonal close-packed lattice with an axial ratio 1.60. The investigation confirms the new equilibrium diagram of the iron–zinc system by Y. Ogawa and T. Murakami. GN

Crystal Structure of Nickel Films. G. P. Thomson. *Nature*, June 15, 1929, page 912.

Films of nickel deposited on rock salt show, on examination by the cathode ray diffraction method, a hexagonal structure, as compared with the normal face-centered cube.

X-ray Pattern of Metallic Crystals. G. B. Deodhar. *Nature*, June 15, 1929, page 909.

Laue diagrams obtained with silver and gold foils suggest that these foils do not recover from the processes of manufacture (anneal) and should be regarded as an assemblage of minute crystals. The space lattice appears to be identical in both metals.

Note on Crystal Structure of the Alpha Copper Tin Alloys. Robert F. Mehl & Charles S. Barrett. *Mining and Metallurgy*, August 1929, page 389.

Being an abstract of technical publication No. 231 of the American Institute of Mining and Metallurgical Engineers. Side of unit face-centered cube and density were determined. Contrary to previously published work, this solid solution is simple substitutional in type. VSP

Aluminum Foundry Makes Use of X-ray Equipment. *Iron Age*, August 15, 1929, pages 406–408.

Describes equipment of Aluminum Company of America at Fairfield, Connecticut. The laboratories of the plant cover chemical and physical work, photo-micrographic studies, and also an X-ray department. Test specimens from every heat poured are analyzed and test bars are pulled. Check is likewise made on all incoming raw material. VSP

The Structure of Pearlitic Grains. (Sur la structure interne du grain de pearlite.) Colonel N. T. Belaiew. *Revue de Metallurgie*, August 1929, pages 424–426.

Relation between the width of lamellae and the angle formed by the crystal with the sectioning plane is briefly described. JDG

The Influence of Deforming on the Transformation Points of Iron and Steel (Ueber die beeinflussung der Umvandlungspunkte von Eisen und Stahl durch Verformung). F. Sauersald & Th. Sperling. *Zeitschrift für Physik*, **56** (7–8), (1929), pages 544–547.

By taking cooling and heating curves during the deformation of a sample rod for tensile tests it could be determined that under the existing conditions the transformation point Ac_1 is shifted to a temperature 7° C. lower, Ac_3 to 4° lower, Ar_3 to a temperature 4° higher. Ar_1 was shifted only 1° maximum. This reduction of hysteresis by deformation was explained mainly by the influence due to deformation on the transformation velocities. It remains doubtful whether the thermo-dynamic functions also are influenced by deformation. Ha

Cohesion and Atomic Structure. S. Dushman. Marburg Lecture—*Advance copy for Proc. Am. Soc. for Testing Materials*, **29** (2), (1929), 58 pages.

The election structure of the atom and the lattice structure of the crystal are discussed in relation to the calculated cohesive forces in solids. The probable reasons for the much smaller magnitude of the actual engineering strength than the theoretical strength are discussed at length, as is the matter of plastic flow at high temperatures. The author points out that there is a wide gap between the facts and present theories of the physicist in regard to cohesion and their application from the engineering point of view. The lecture is an orderly arrangement of the scattered facts and theories that bear on the problem of metallic cohesion from the philosophical viewpoint of the physicist. While this thoughtful résumé of the subject covers too much ground for detailed abstracting, metallurgists will find it of interest. HGW

X-ray Investigations of the Iron–Manganese System. (Röntgenographische Untersuchungen über das System Eisen–Mangan.) W Schmidt. *Archiv für Eisenhuttenwesen*, Oct. 1929, pages 293–300.

An X-ray investigation of the iron-manganese diagram led to the discovery of an interesting new phase, called ϵ-iron by the author. The α-iron extends from 0–20% Mn, the lattice constant expanding from 2.857 A. U. to 2.871 A. U. (±0.001). The ϵ-phase exists between 12 and 29% Mn, the constants increasing as follows; α from 2.532 to 2.543 and ϵ from 4.061 to 4.082; the axis ratio remains constant. The α-phase extends from 16 to 60% Mn with an increase of the lattice constant from 3.586 A. U. to 3.616 A. U. All 3 solid solutions ferrite, austenite and ϵ-phase agree very well with the Vegard law. β-Mn is only found between 62 and 98% Mn, while the α-Mn is only stable in low iron alloys at room temperature. The author points out that the ϵ-phase closely approaches the face centered cubic lattice of α-iron. Therefore, no difference in structure could be found metallographically and dilatometric and thermal analyses also gave no indications of this phase. CK

The Eutectic Composition of Copper and Tin. G. O. Hiers & G. P. de Forest. *American Institute of Mining Metallurgical Engineers, Technical Publication* **241,** 13 pages.

A study was made of the tin-rich region of the Cu-Sn diagram, resulting in the location of the eutectic at 0.94% Cu. Methods, apparatus and polishing technique are stated and photomicrographs given. EF

Determining Orientation of Crystals in Rolled Metal from X-ray Patterns Taken by Monochromatic Pin Hole Method. W. P. Davey, C. C. Nitchie & M. L. Fuller. *American Institute of Mining Metallurgical Engineers, Technical Publication* **243,** 10 pages.

This paper describes a new method for orientation studies irrespective of the degree of preference of orientation and which may be used where one preferred orientation, a system of orientation, or several systems of orientations must be dealt with. The paper illustrates this method as applied to rolled zinc. EF

Studies in Metal Crystal Orientation: I—Determination of Orientation of Metallic Single-Crystal Specimens by High Voltage X-rays. T. A. Wilson. *American Institute of Mining Metallurgical Engineers, Technical Publication* 210, 18 pages.

The interior orientation of crystals of silicon steel has been determined by X-rays according to the Laue-method. The apparatus employed to obtain photographs and the solution of these either by applying gnomonic projection alone or by applying the stereographic-gnomonic double net are described. EF

Results of X-ray Material Testing. (Ergebnisse der Materialprüfung mit Röntgenstrahlen.) H. Becker-Rose. *Chemische Fabrik*, May 8, 1929, pages 229–230; May 29, 1929, pages 270–271.

Review of X-ray investigations according to Debye-Scherrer and Laue-method, applied on catalyzers, ceramic products, minerals and metals. EF

The Crystal Grains in Castings. (Les Grains Cristalline des Moulages.) D. Glazunow. *La revue de la fonderie moderne*, Sept. 10, 1929, pages 404–417.

The author develops the different theories of crystallization as put forth by various scientists and gives the principles of crystallization. A system of crystals is considered in connection with the different types of crystallization diagrams. GN

Modern Conceptions of Crystal Growth. (Neuere Vorstellungen über das Wachstum der Kristalle.) W. Kossel. *Metallwirtschaft*, Sept. 6, 1929, pages 877–881.

The results of intercrystalline changes being known, due to intensified study of the last years, the author approaches this problem from a different angle, namely to explain the causes of the reversible process: crystal growth and disintegration. The equilibrium theory is critically discussed and the influence of solution companions (Lösungsgenossen) is mentioned. Experiments with growing crystals are summarized and crystals built up of ions and metal atoms are considered including catalytic effect, surface attack, passivity and behavior of metal electrodes in electrolysis. EF

The Coalescence of Pearlite. J. H. Whiteley. *Paper before Iron and Steel Institute*, Sept. 1929, 8 pages.

In hypo-eutectoid steels α-iron solid solution is transformed into pearlite over a small range of temperature immediately below the Ac point. The author shows that coalescence resulting in the formation of cementite borders to pearlite occurs within this temperature range before all the α-iron is transformed. This is due to the transference of carbide by diffusion from the α-iron to the adjacent pearlite areas. Therefore, the longer the time during which the steel is cooling through the An_1 range, the greater will be the tendency to coalesce. Steels very low in manganese showed the most marked effects. Coalescence was not obtained with samples containing more than 1.0% of manganese. AEH

The Solubility of Carbide in Ferrite. H. A. Dickie. *Paper before Iron and Steel Institute*, September 1929, 25 pages.

The physical effects of the solubility of carbide in ferrite have been investigated in a wide range of steels, including alloys containing up to 7 of nickel, 2 of manganese, 5.5 of chromium, 4.5 of nickel with 1.5 of chromium and Armco iron. Changes due to tempering effects, such as spheroidization have been eliminated from the results by the methods of heat treatment adopted, and the solubility curves for the eighteen steels used have been determined and reduced to terms of carbon content. AEH

The Shape of Graphite. F. Roll. *Foundry Trade Journal*, Aug. 15, 1929, page 124.

Translated from article appearing in *Die Giesserei*, **1928**, pages 1270–1274. Describes method evolved by author to reconstruct actual volumetric shape of graphite in cast iron. VSP

Experimental Data on the Equilibrium of the System Iron Oxide–Carbon in Molten Iron. A. B. Kinzel & J. J. Egan. *Mining & Metallurgy*, August 1929, page 390.

Being an abstract of Technical Publication 230 of the American Institute of Mining and Metallurgical Engineers. Describes method of determining FeO-C equilibrium constant. Indicates that 5×10^{-4} is the value of *m* at 1550° C. and one atmosphere pressure. Carburization ot melt does not take place in presence of Co. VSP

Recrystallization of Electrolytic Copper after Hot Rolling. (Die Rekristallisation vo Elektrolytkupfer nach dem Warmwalzen.) W. Tafel. *Zeitschrift für Metallkunde*, August 1929, pages 265–267.

Previous investigations with soft iron are continued with electrolytic copper in order to throw light upon the different appearance of recrystallization after hot rolling in contrast to forging. After rolling at 900 and 700° C. respectively, samples were taken, etched by a new method and grain size was determined according to Jeffries' method. The results of the microscopic investigations are represented in diagrams in which grain size is plotted against temperature of rolling. The divergencies from previous investigations along those lines are explained. EF

Practical X-ray Investigations. (Technische Roentgenstrahlenuntersuchungen.) A. Herr. *Elektrotechnik und Maschinenbau*, April 1929, pages 329–332.

The present state of X-ray examination for routine testing is given by examples and the economy proven by calculations. The Laue method and structure diagrams are emphasized for inspecting products. EF

Installations for X-ray Testing of Materials. (Anlagen fuer Werkstoffprüfung mit Roentgenstrahlen.) Dr. Painsipp. *Elektrotechnik und Maschinenbau*, April 21, 1929, pages 33–337.

The equipment available on the market is reviewed and some practical features in regard to cost, radiation-proof protective screens and high tension protection devices, etc. are discussed. EF

Influence of the Apparatus Type on the Economical Use of X-ray Tube. (Einfluss der Apparattype auf die Strahlungsausbeute der Roentgenroehre.) J. Zakovsky. *Elektrotechnik und Maschinenbau*, April 21, 1929, pages 337 341.

The different types on the market are compared and conclusions in regard to economical application are drawn. EF

The Influence of the Voltage Curves upon the Image in X-ray Technique. (Der Einfluss der Spannungskurven auf die Bildgebung in der Roentgentechnik.) G. Seigler. *Elektotechnik und Maschinenbau*, April 21, 1929, pages 342–345.

The superiority of the rotating rectifier and the constant voltage apparatus in comparison with the four tube apparatus—providing the same peak values of voltage and equal tube currents are used—has been proved especially in case of more pronounced filtering. The curves for the screen light intensities as obtained with the different apparatus under various filtering conditions are given. Comparison of the smaller degree of brightness is made and the influence upon load investigated. EF

Practical Applications of X-rays for the Examination of Material According to the Absorption Method. (Praktische Anwendungsgebiete der Roentgenuntersuchung von Werkstoffen nach der Absorptionsmethode.) E. Petertiel. *Elektrotechnik und Maschinenbau*, April 21, 1929, pages 345–348.

Advantages of radiographic investigations of material are considered and a great number of successful applications for daily use are illustrated. EF

Metallography and Macrography

Relation between α-Veins and A_3 Transformation (Ueber den Zusammenhang zwischen α-Aederung und A_3 Umwandlung.) E. Ammerman- & H. Kornfeld. *Archiv für Eisenhüttenwesen*, Oct. 1929, pages 307–311; *Stahl und Eisen*, Aug. 15, 1929, pages 1192–1195.

The authors base their investigations on the results of H. S. Rawdon and T. Berglund in reference to unusual network formations in ferrite. It is shown that a recrystallization below A_3 results in a ferrite free from network. Only those parts of ferrite which pass into the α-state exhibit network formation. Mechanical work below the A_3 has no influence on the phenomenon described. CK&GN

Gold–Mercury System. I. N. Plaksin. *Journal of Russian Phys. & Chem. Society*, LXI, **4** (1929), pages 521–534.

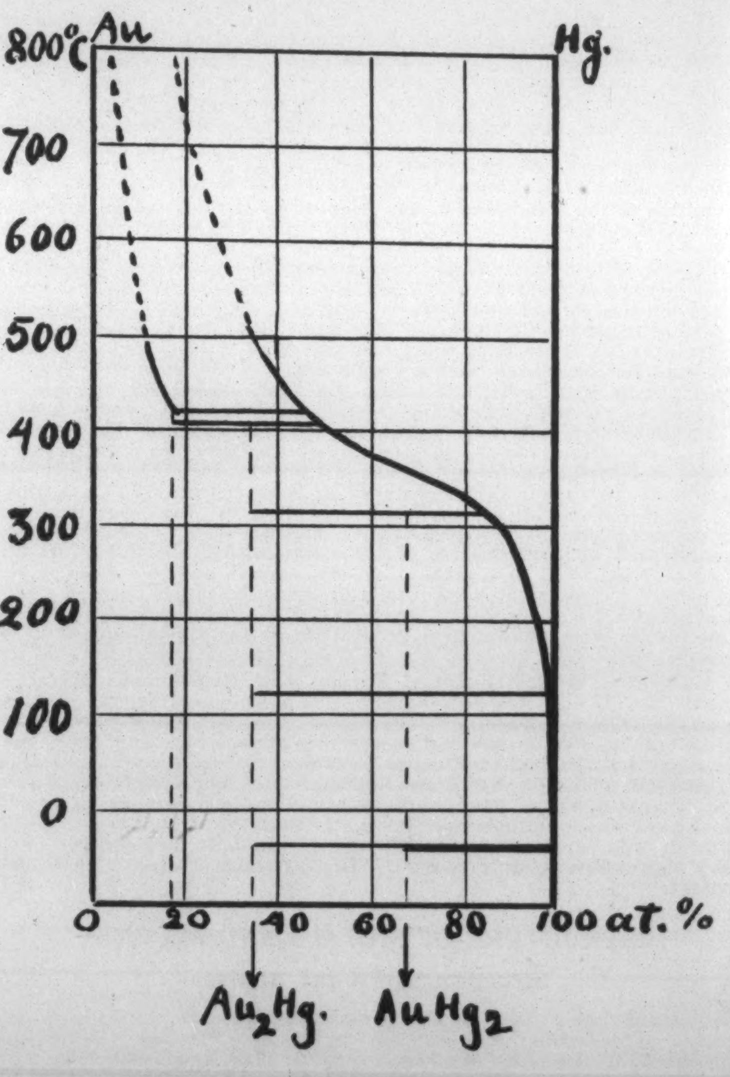
The first data on the solubility of gold in mercury were given by Henri (*Phil. Mag.*, **9**, 468 (1855). These experiments were then repeated by Katsanzeff (*Bull. Soc. Chim.*, **30**, 20 (1878)), who established the solubility of gold in mercury as follows:

° C.	Solubility
0	0.110%
20	0.126
100	0.650

As to the solubility of mercury in the gold (solid solution) it was believed by some authors that the solubility limit of mercury in gold is about 10%. The chemical compositions of the natural amalgams of gold fluctuate within wide limits. According to V. I. Vernadsky these limits are:

Hg	Au	Ag	Pt
57.4–61.0	34.2–41.6	0–5.0	0–0.1

In the present work chemically pure gold and mercury were used. Thermoanalysis was adopted as a chief method of investigation and it was carried out on the Kurnakoff's recording pyrometer (*Zeits. f. anorg. Chemie.* 42, 184 (1904). The specimens were placed in the apparatus made of glass, which was evacuated to 15 mm. of mercury and then sealed. The weights of specimens were 78–83 grams. The thermocouples employed were: Au-Pt couple for the temperatures above 0° C. and copper-constantan couple for the temperatures below 0° C. (At temperatures below 0° C. a sensitive galvanometer of the Hartmann–Braun type with a mirror attachment was used.) The results of this work were illustrated by the diagram below and conclusions drawn by authors were as follows: (1) There are two compounds $AuHg_2$ and Au_2Hg in which gold enters into combination with mercury. (2) The first compound ($AuHg_2$) is stable up to 310° above which temperature it is disintegrated into Au_2Hg and Hg. (3) At 420° C. the compound Au_2Hg is dissociated and two solutions are formed: liquid solution of gold with mercury and solid solution of mercury in gold. (4) The maximum concentration of mercury in the gold is 16 atomic percent. (5) There are two polymorphic transformations of $AuHg_2$: one at 122° C. and another at −36° C. (6) There is a polymorphic transformation of Au_2Hg at 402° C. observed for the alloys containing from 51 to 84 atomic percent of gold. (7) Liquidus may be divided into 6 parts with corresponding critical points as follows: I. at 36° C.; II. at 122° C. and 1.3 atomic percent of Au; III. at 310° C. and 13% of Au; IV. at 402° C. and 50.3% of Au; V. at 420° C. and 55.6% of Au. Eutectic point is located very close to the ordinate corresponding to the pure mercury and its temperature almost coincides with the freezing temperature of the pure mercury. The paper is illustrated by a number of micrographs. A special apparatus was developed by the author permitting the observation and photographing of microstructures of gold alloys at different elevated temperatures. AIK



A Method to Determine the Inclusions of Slags and Some Practical Results Obtained by this Method. (En slagg-bestämnigsmetod och några pratiska resultat av densamma.) H. Kjerman. *Jernkontorets Annaler*, April 1929, pages 181–199.

The author describes a microscopic method to determine the slag content of steels. Generally spoken, the inclusions are in the most cases solid solutions of iron and manganese silicates, or iron sulphite and manganese sulphide. He examined the slags of different steels. Relations between slag content and physical properties are stated with special regard to acid open hearth steel. Chromium ball bearing steel contained, in spite of the same content of sulphur, more sulphide inclusions than acid plain carbon steel. Investigations on the sulphide content of chromium ball bearing steel show that a decrease of grain size of the sulphide inclusions, with increasing manganese content in the steel baths, could only be noticed when ferromanganese is charged at the beginning of the melting period, i. e., together with pig iron and scrap. A decrease in quantity of the sulphde inclusions could not be observed. GN

The Influence of Graphitization on Cast Iron. E. Diepschlag. *Foundry Trade Journal*, July 11, 1929, pages 23–26.

A paper presented at the International Foundry Congress states that if cast iron having coarse grained graphite crystals is melted and then cooled, the remelted sample will have coarse grained graphite deposits. Differentiates form and quantity of graphite crystals in pig iron in the following manner: (1) hypereutectic graphite separated while the mass is liquid; (2) graphite in compact grains separated near eutectic line; (3) graphite in thin leaves; (4) graphite in very fine state; (5) graphite in soft and porous flakes. Describes and gives results of microscopic examinations of graphite structure made after the manner of Hamasumi. Cites numerous authorities. VSP

Preparation of Aluminum Alloys for Microscopic Analysis. (Herrichtung von Aluminiumlegierungen für die mikroskopische Untersuchung.) H. Choulant. *Zeitschrift für Metallkunde*, June 1929, pages 197–199.

Etching media and methods employed for etching of aluminum alloys such as duralumin were investigated. The method is described and its application to cast alloys, quenched and annealed duralumin is demonstrated. EF

Methods of Research in Metallography. G. Masing. Paper before Institute of Metals, September 1929, 19 pages.

The author describes the fundamental principles underlying the research methods employed in investigations on the constitution of alloys and in physical metallography and shows that researches on the constitution of alloys must be based on the well-established thermodynamical laws of heterogeneous equilibria. The experimental methods are however not sufficient for accurate work and need to be improved in precision and amplified (especially X-ray technique). The most important improvement required is the development of a method for the rapid attainment of equilibrium in an alloy. Besides the establishment of equilibrium diagrams the study of constitution nowadays demands an investigation of the condition of alloys far removed from the state of equilibrium; the theoretical and experimental aspects of this problem are considered. The greatest interest is evinced in the study of plastic deformation in physical metallography and in hardening, recrystallization and other phenomena. Emphasis is laid upon the importance of using precise physical methods in this field. AEH

On the Equilibrium Diagram of the Iron—Molybdenum System. Takeshi Takei & Takejiro Murakami. *Transactions American Society for Steel Treating*, September 1929, pages 339–371.

Includes discussion; 35 micrographs. The equilibrium diagram of the iron molybdenum system has been studied by microscopic investigation, electric resistance, dilatometric and magnetic analyses. In this system two intermetallic phases (ϵ) and (η) exist consisting of compounds Fe_3MO_2 and FeMO. These phases are derived by the peritectic reactions, melt + $\eta \rightleftharpoons \epsilon$, and melt + $\delta' \rightleftharpoons \eta$. The former yields a eutectic with α iron, dissolving molybdenum at 2625° F. (1440° C.) in the range of composition 38 to 50% molybdenum; the latter decomposes to the ϵ phase and molybdenum dissolving iron at about 2155° F. (1180° C.). The solubility of molybdenum in α-iron is 38% at 2625° F. (1440° C.), and it decreases to 6% at room temperature. The A_2 point of the solid solution is slightly lowered as the molybdenum content increases, while the A_3 point rapidly rises to 3% molybdenum. In alloys containing more than 63% molybdenum a eutectoid is found, consisting of the η-phase and molybdenum dissolving iron. ESC

Preparing Thin Specimens for Microscopic Examination. R. A. Ragatz. *Mining & Metallurgy*, August 1929, pages 372–379.

Gives a résumé of tests carried out and suggests best methods for handling various types of specimens. Numerous illustrations are given. Includes a table giving the etching characteristics of various metals mounted in different media, and corrosion resistance of the media to common etchants. VSP

The Critical Examination of Steel Castings. G. F. Gillott. *Foundry Trade Journal*, July 18, 1929, pages 38–40. (To be continued.)

Paper read before the International Foundrymen's Congress. The methods employed in studying sectioned-ingots are macroscopical and microscopical. Sulphur printing gave a graphic representation of the degree of heterogeneity, based on unequal distribution of sulphide. Sulphur prints usually indicate regions which may be better examined microscopically. Microscopical examination shows efficiency of the annealing received. Discusses the importance of annealing and gives results. Presents numerous illustrations. VSP

PHYSICAL, MECHANICAL AND MAGNETIC TESTING

Testing of Magnetic Steels. (Die Prüfung von Dauermagnetstahl.) W. Vertel. *Stahl und Eisen*, Oct. 3, 1929, pages 1449–1454.

Report No. 155 of the materials committee of the Verein deutscher Eisenhüttenleute. The report describes the methods applied to date for testing magnetic materials. A new apparatus, the Bosch magnetic tester, built by Hartmann and Braun, Frankfort, Germany, permits obtaining reliable and sufficiently exact figures of rolled as well as quenched samples in a short testing time. Construction, working manner and gauging of the apparatus are represented. The results of comparison tests with various apparatus are given. The apparatus fulfills an urgent need. GN

Acoustic Meter for Elongation Measurement. (Akustischer Dehungsmesser.) Kurrein. *Werkstattstechnik*, Sept. 15, 1929, pages 541–542.

Description of the O. Schaefer acoustic elongation meter built by H. Maihak, Hamburg, Germany. The tone of a piano wire, attached to the member is changed by elongation. The meter is built so that the deviation of the tone and elongation have a linear relation to one another. The application of the method covers a broad field. GN

Materials in Machine Construction. H. F. Moore. *Mechanical Engineering*, Oct. 1929, pages 739–743.

The author outlines the general principles for testing materials, which must be known to the machine designer. GN

A Modern Method for Testing Materials in the Plant. (Ein neutzeitliches Verfahren zur werkstattmässigen Prüfung von Werkstoffen.) C. Sonannini. *Werkstattstechnik*, September 1, 1929, pages 495–496.

The most generally applied hardness tests, Brinell and Rockwell, are described, and the disadvantages, due to the errors of the subjective reading are mentioned. The described Gerber-hardness tester eliminates this by applying a direct load of weights and an automatic registration of the depth of indentation. The new apparatus can also be applied to Brinell and Rockwell tests. GN

Comparison of Practical and Laboratory Tests with Tools of Hardened Steel. (Tämförelse mellan praktiska prov och laboratorie prov pa verktyg av härdat stal.) A. Lundgren. *Jernkontorets Annaler*, August 1929, pages 375–389.

The investigation was made to determine the relation between the physical properties and the cutting qualities of tools. The examination of five different groups of tool steels, which were quenched and heat-treated by different methods show the influence of a proper heat-treatment of tool steels on their cutting qualities. The bending strength, the Rockwell hardness and the notch toughness were tested. Also the resistance to wearing down, as it seems this should be tested in order to estimate the value as a cutting tool. GN

Bending Strength of Hardened and Tempered Tool Steels. (Böjnnigohallfasthsten hos härdat och aulöpt verktygsstal.) K. Amberg. *Jernkontorets Annaler*, June 1929, pages 280–299.

The author investigated the relations between bending strength and other physical properties of tool steels. Plain carbon steels (0.75–1.21 C), alloy steels with a content of chromium (0.64–1.46%) or tungsten (0.55–2.03%) and two high alloy steels (Cr 12.26%, W 1.60%) and Cr 4.14%, W 17.6%, Va 0.80%, respectively) were examined. After quenching and drawing, bending strength, electric conductivity and Rockwell hardness were determined of all the steels. A relation between hardness and bending strength of steels quenched could not be determined, it was found for the drawn carbon steels. The highest values of bending strength of drawn steels can be attributed to the transformation of γ-iron into troostite. GN

Discontinuities of Magnetization in Iron and Nickel. C. W. Heaps & Josiah Taylor. *Physical Review*, September 15, 1929, pages 937–944.

The discontinuities of magnetization were observed in iron and nickel and recorded photographically. The number corresponding to a given small change of magnetizing force has been determined for different speeds of magnetization. For high speeds there appear to be more and smaller discontinuities as the speed is slightly reduced. If the speed is greatly reduced, however, there are fewer discontinuities in ordinary specimens than for high speeds. The length of the portion of material associated with such discontinuity is estimated to be 2 or 3 mm.; the volume is of the order 10^{-7} cm.^{3}

Corresponding Values of Notch Impact Tests with Different Types of Notch Samples. Discrepancies of the Values. (Verhältniszahlen zwischen den mit verschiedenen Probenformen erreichten Kerbzähigkeitszahlen. Streuung beim Kerbschlagversuch.) R. Mailander & F. P. Fischer. *Krupp'sche Monatshefte*, July 1929, pages 99–102.

The paper gives data of comparison tests with two different types of samples, Mesnager and the Charpy sample. The Mesnager sample was employed as it is the standard in several countries and the Charpy sample as it is most generally used. Carbon steels, nickel steels and chromium-nickel steels were examined. GN

The Technical Tests for Hardness. (Die Technische Harteprüfung.) M. Moser. *Krupp'sche Monatshefte*, June 1929, pages 62–73.

The author describes all the different methods and apparatus employed for testing the hardness of materials. The advantages and disadvantages of all these different tests are discussed, the instruments are described and the constructions are shown in 33 figures. GN

The Use of Mirror Extensometer of Martens for Tensile Testing at Elevated Temperatures. (Emploi de l'extensometre a miroirs de Martens pour les essais de traction a chaud.) Leon Gillet, Jean Galibourg & Michel Samsoen. *Revue de Metallurgie*, August 1929, pages 427–434.

In an accurate determination of physical properties at elevated temperatures the influence of the increment of load and changes in the strength of metal must be minimized. An apparatus for this must have a very sensitive extensometer and means for holding specimens under unvariable loads for long periods. A suitable apparatus is described. All experiments were conducted at 450° C. Increasing loads change instantaneous elongation from a straight line to a curve function. With sufficiently light loads the elongation reached directly after application of the load remains stationary. With higher loads it increases with the time, reaching a maximum in about two hours after which further elongation does not take place. With still higher loads specimens elongate rapidly directly after loading until the fracture occurs. Complete data of 14 alloy steels studied with this apparatus are given. Elastic limit increases at a given temperature with the increase in carbon content. Composition has a pronounced influence and the elastic limit increases in steels in order: carbon steels, nickel, nickel-chrome, nickel-chrome-molybdenum. Values range from 5.7 kg./mm.^{2} to 29 kg./mm.^{2} for the latter. JDG

Testing of Metals and Alloys by Crushing and Extrusion at Elevated Temperatures. (Les essais a chaud des metaux et alliages par compression et par filage.) Albert Portevin. *Revue de Metallurgie*, August 1929, pages 435–444

A study of deformation produced by pressure on cylindrical specimens made of magnesium and its alloys at temperatures up to 400° C. Three types of deformations were observed and investigated. The behavior of the same metals during extrusion into wires at different temperatures was investigated. The extrusion press is described and formulae for expression of the mechanism of deformation are given. JDG

A Magnetic Material Testing Method. (Eine magnetische Materialprüfungsmethode.) W. Gerlach. *Metallwirtschaft*, Sept. 6, 1929, pages 875–877.

The author reports on a new testing method worked out at the University of Tübingen to discover mechanical inhomogeneities in ferro-magnetic material by means of magnetic measurements. Data collected from experiments, illustrations and references of former investigations along these lines are given. EF

On Rebound Hardness, Drop Hardness and their Relation to Temperature. (Ueber die Rücksprunghärte, die Fällharte und ihre Abhängigkeit von der Temperatur.) F. Sauerwald. F. Rakoski & U. Schylla. *Metallwirschaft*, Sept. 27, 1929, pages 929–942.

A new method for the determination of rebound hardness and simultaneous measurement of drop hardness was developed, suitable for investigations at elevated temperatures. It could be proved that Al and Cu within a temperature range of 100–300 and 200–400° C. respectively exhibit constant rebound hardness. The specific displacement work is nearly a straight line function of temperature. Measurements of rebound hardness, which fundamentally depends on elongation and elastic limit, may be considered as a method which determines the amount of energy which can be absorbed by a material under elastic deformation. At present, dependence on temperature must be explained in such a way that elongation and proportional limit within a certain range of temperature yield a constant product or a corresponding function. EF

ELECTRO-CHEMISTRY

Electrometallurgy

Production of Aluminum by a Direct Process. (A propos de la fabrication directe de l'aluminium.) *Journal du four electrique*, August 1929, page 260.

Comments on patents (French) granted Jan. 21, 1927, and Aug. 30, 1928 (642550), to Société pour l'industrie de l'aluminium of Neuhausen for production of pure aluminum by electrolysis of anodes made by direct reduction of aluminum bearing materials in an electric furnace with carbon. Anodes are composed of aluminum ferro silicon and are electrolyzed in molten salt bath. Silicon is intentionally added to reduce the solubility of Fe. JDG

Electroplating

Under Coats and Striking Coats in Plating. Electrographer. *Brass World*, August 1929, pages 185–186.

A brief discussion of preliminary deposits before final plating and finishing. In preparing for chromium deposits "it is best to hasten slowly." WHB

Racks for Chromium Plating. *Brass World*, August 1929, page 188.

The Belke Mfg. Co., Chicago, Ill., has designed six standard racks for chromium plating. The racks are built on spines of heavy composition with tips that are replaceable and adjustable. The standard racks with work attached are illustrated. WHB

Comparison between Metal Coating Processes. *Brass World*, August 1929, page 193; *Brass World*, July 1929, pages 170–171.

Four illustrations referring to the difference in the composition of coatings between various metal coating processes are shown. WHB

Sodium versus Potassium Silver Plating. *Brass World*, August 1929, pages 190–192.

An abstract of a paper read before the Electroplaters' & Depositors' Technical Society. On the basis of finish obtained on plated flatware, and of the loss during finishing, there is no appreciable difference. The finishing loss on spoons showed NaCN 4.5% superior to KCN. A brief discussion is included. WHB

Plating Solution Control Apparatus. *Brass World*, August 1929, page 192.

The apparatus, known as the "C. I. C. Titration Set" is manufactured by the Walter S. Wood Co., Boston, Mass. The set is enclosed in a dustproof box which serves as a support for the apparatus when in use. Results are presented in terms of ounces per gallon and carefully prepared instructions make chemical knowledge unnecessary for its manipulation. WHB

Engineering Applications of Chromium Plating. Frank P. Romanoff. *Journal of the Western Society of Engineers*, August 1929, pages 430–436.

A survey of the uses of chromium plate and its advantages. Emphasis is placed on the engineering applications. WHB

Electrolytic Zinc Practice at Great Falls and Anaconda. A. E. Weggin & R. B. Coples. *Engineering & Mining Journal*, Aug. 24, 1929, pages 319–324.

The processes and equipment are covered. MBR

Refinery Production of Nickel Salts Used for Electroplating. S. Skowronski. *Engineering & Mining Journal*, Oct. 5, 1929, page 544.

Brief note on purification of electrolyte in refineries. MBR

Electrolytic Recovery of Metals. (Elektrolytische Metallgewinnung.) G. Eger. *Chemische Fabrik*, July 10, 1929, pages 333–335; July 31, 1929, pages 351–352.

The author presents a survey of the most important industrial methods of electro-deposition. Cu and Zn are preferably discussed and mention is made of the electro-deposition of Ag, Au, Pb, Sn, Ni, Co, Fe, Cd and Cr. EF

Studies of Overvoltage on Metals. P. Sederholm and C. Benedicks. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 179–193.

The authors have empirically established that the regular, half immersed hydrogen electrode is completely reversible along a straight volt-ampere line, even within the region of oxygen discharge, at least with anodic currents below 1 milliampere. It has also been found that the same condition prevails when the H-electrode is totally immersed. Only the reversible portion of the volt-ampere curve for the discharge is a very restricted one. A smooth, bright platinum gauze electrode is shown to give the same potential as an electrode of platinized platinum provided some O_2 has been precipitated on it, the O_2 acting as a depolarizer. In the same manner as overvoltage occurs on the liberation of H_2, overvoltage also occurs on the discharge of O_2. For both gases, the volt-ampere curves obtained exhibit reversibility, corresponding to the "oxygen electrode." In this case H_2 acts as a depolarizer. The potential difference between the "oxygen electrode" and the "hydrogen electrode" in a given solution has been found to be 1.48 volts in comparison with 1.23 volts given by Nernst based on theoretical considerations. During electrolysis there is a complete polar symmetry between the behavior of H_2 and O_2. In conclusion some theoretical interpretations of the nature of overvoltage are presented. EF

The Use of Tantalum as Cathode for the Electrodeposition of Copper. L. W. Strock & H. S. Lukens. *Paper before Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 9–18.

The use of tantalum as a substitute for platinum as cathode material for electro-analytical determinations is discussed with particular regard to surface changes of the cathode. A high starting current density of 3 amp./cm.^{2} is recommended and further details of procedure are given. EF

Cathode Potentials and Electrode Efficiencies of Copper in Copper Cyanide-Sodium Cyanide Solutions. G. M. Smith & J. M. Breckenridge. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 39–46.

The paper gives a record of the kinetic potentials of a copper cathode and electrode efficiencies, using various current densities and concentrations of copper cyanide in sodium cyanide. EF

The Determination of Sulphate in Chromic Acid and in Chromium Plating Baths. H. H. Willard & R. Schneiwind. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 61–74.

The whole chemistry of H_2SO_4 determinations in CrO_3 according to the various methods is considered. As a rapid control method for plating baths, a measurement of the turbidity produced by the $BaSO_4$ is found to be satisfactory. EF

A Turbidimetric Method for the Determination of the Sulphate Content of Chromium Plating Baths. L. E. Stout & A. W. Petchaft. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 109–119.

This paper presents a new and rapid turbidimetric method for the determination of the sulphate content of chromium plating baths. EF

Some Chromium Plating Experiments. C. M. Alter & F. C. Mathers. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 329–335.

The authors find that chromium deposits more easily upon copper or iron than on platinum or graphite. Cobalt salts in the chromic acid bath and periodic reversal of the current prevent the deposition of chromium which furthermore is reduced or prevented by stirring the bath or momentarily lifting the cathode out of it, while Cu, Ni, Fe and various other metals in the form of chromates and silica gel were without effect. Current efficiencies were increased by the use of a porous diaphragm. EF

Chromium Plating Stands Severe Abuse on Electric Range Parts. A. Bernsteiner. *Electric Journal*, Oct. 1929, page 491.

Pans were filled with water and placed over the highest temperatures on the platform during the day and alternately various cold liquids, vinegar salt solution and fruit juices were spilled on the overheated platform. After 11 days the surface was cleaned of the ugly crust that had accumulated. The chromium surface was unaffected and bright. WHB

The Use of Non-ferrous Metals in the Electroplating Industry. Floyd T. Taylor. *Brass World*, Oct. 1929, pages 235–237.

An address before the Institute of Metals and Iron & Steel Divisions. A brief review of the present state of the art. "Corrosion has to do with the metal underneath the coating; tarnish is an atmospheric discoloration of the outer surface of the coating. Plating with copper, nickel, zinc, cadmium and the precious metals are briefly discussed. Electrodeposition has increased since the war for four reasons. First, in making munitions; second, the development of labor eliminating process-stabilizing, electroplating machinery; third, use of color combinations; fourth, increase in use of electroplating machinery. VSP., WHB

New Type Barrel Plating Machine. *Brass World*, Oct. 1929, page 245.

The Lustre Co., Inc., St. Louis, Mo. has introduced a new type of cylinder plating machine for copper, brass, zinc, cadmium or nickel. Advantages claimed are: elimination of chains, cables, belts and overhead obstructions, mechanical gears in solution, all-formica cylinder of rigid construction, gears always meshed, simple, easy lifting of cylinder, automatic clutch permitting free swinging of cylinder and a jacketed tank to regulate temperature of solution. WHB

Simple Sulphate Test Apparatus. *Brass World*, Oct. 1929, page 245.

The "Kocour" test set for determining the sulphate content of chromium plating solutions is marketed by the State Mfg. Co., 4724 South Turner Ave., Chicago, Ill. The set included: a centrifuge with head and shields, two calibrated centrifugal tubes, one 8-oz. bottle each of Solutions A and B, pipettes and a card of directions. Analyses of these solutions are given in a direction card, and results with this apparatus check with the chemical methods to the nearest 0.02 oz./gal. WHB

The Measurement of pH in Nickel Plating Solutions. W. Blum & N. Bekkedahl. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 287–313.

The adaptability of colorimetric methods for the determination of pH with the object of controlling the essential uniformity of nickel plating baths is investigated and measurements with the hydrogen and quinhydrone electrode are carried out. EF

Electrode Potentials of Copper Anodes and Copper Cathodes. E. F. Kern & R. W. Rowen. *Paper before American Electrochemical Society*, Pittsburgh, Sept. 19–21, 1929, pages 337–350.

The electrode potentials of copper anodes and cathodes were determined, and the effect upon the electrode potentials by varying the temperature and composition of the electrolyte, by the composition and physical character of the anodes, and by the additions to the electrolyte of glue and sulphite-waste residue. EF

METALLIC COATINGS OTHER THAN ELECTROPLATING

Coloring of Metals. (Metallfärbung.) H. Kurrein. *Chemiker Zeitung*, August 7, 1929, pages 209–210; August 12, 1929, pages 630–631.

Review of methods applied for coloring and coating metals by the galvanic coating process and the chemical dying possibilities. EF

Metal Coatings. *Electrician*, Nov. 8, 1929, page 560.

A pistol spraying process is sponsored by the Metals Coating Co., Ltd., for coating with metal to thicknesses of 0.001 in. upwards articles and parts of metallic or non-metallic construction. The metal is normally used in wire form but for special purposes metal dust or powder may be employed with a modified form of apparatus. The pistol is connected by rubber hose to standard acetylene and oxygen cylinders and to a suitable supply of compressed air. Applications of the spraying to cylindrical parts, the interior surfaces of tubes and to bulk coating of small parts are outlined. WHB

INDUSTRIAL USES AND APPLICATIONS

A Non-Porous Aluminum Alloy for Vacuum Chamber Castings. E. C. Nichols. *Jour. Opt. Soc. of America*, Sept. 1929, pages 164–165.

In making a vacuum spectrograph chamber, considerable difficulty has been met in getting non-porous castings. A chamber 6″ × 6″ with $^3/_8$″ walls cast from 95% Al, 5% Si poured at 1250° F. was found non-porous, and held a vacuum of 0.008 mm. of Hg for a week. Caution is given to keep the molten metal away from products of combustion, else gas holes may result. Annealing at 750° F. for 4 or 5 hours by electric heating. followed by air cooling is recommended as giving a closer grained material,

New Low-Sulphur Iron for Ingot Molds. *Iron Age*, August 1, 1929. page 280.

Describes an ingot mold iron to resist cracking of molds through sudden expansion and slow contraction. This metal has been developed by the Vulcan Mold & Iron Co., Latrobe, Pa., and is known as Vulc-iron. Vulc-iron is treated to reduce its sulphur content to an average of 0.035%, and it is guaranteed under 0.05% of sulphur. Test molds showed an average improvement of 25% over direct metal ingot mold iron. VSP

Light Alloys for Aircraft. *Iron Age*, September 5, 1929, pages 615–616, 646.

A digest of several papers presented at the aeronautical meeting held jointly by the Society of Automatic Engineers and the Aeronautical Chamber of Commerce of America at Cleveland. Discusses briefly the wide variety of aluminium alloys used and gives table showing the properties of the various alloys. VSP

Bi-Metal. (Bimetall.) W. Rohn. *Zeitschrift für Metallkunde*, Aug. 1929, pages 259–264.

The author gives the definition of bi-metals and fully outlines the mode of operation of those metals increasingly employed for the construction of of electrical and other instruments. The heat expansion of the more important metals and alloys are given in a diagram and the most suited alloys are recommended in regard to fixed ranges of temperature. The disadvantage of Al is given. The importance of some physical properties as strength, hardness and elasticity are considered and practical results with invar-lead are illustrated. Invar-Ni, Constantan, Monel, Fe-Ni-Mo are especially recommended. The deflection, when heated, of a large number of commercial bi-metals in relation to the temperature and current flowing through the bi-metal are discussed. Difficulties met with Cu-Invar are successfully overcome by the application of Cu alloyed with Be. The specific resistance of different bi-metals for electrical purposes are given in a table. The geometrical dimensions exert an influence upon the bending and working capacity which are considered by the author and verified by experiments. The author concludes with some practical considerations in regard to welding, rolling, soldering, riveting, screwing, etc. EF

Modern Light Alloys and Their Application to Aircraft Engine Design. G. D. Welty. *Journal Society Automotive Engineers*, Nov. 1929, pages 469–473.

Cleveland Aeronautic Meeting Paper. Includes discussion. Chemical composition, physical properties and application of aluminum as well as magnesium base alloys are given in detail. Special purpose alloys are mentioned, as for instance a new aluminum alloy for pistons, which is used commercially. The development of magnesium-base alloys is outlined, and their properties compared with those of the aluminum alloys. GN

Locomotive Forgings. Lawford H. Fry. *American Machinist*, September 5, 1929, pages 411–412.

Abstract of paper presented at A. S. S. T. meetings in Cleveland, Sept. 9–13. A discussion of the manufacture of locomotive forgings from the molten metal to the finished product with particular attention to the structure of the ingot and its influence on the character of the forging. The types of steel ordinarily used for forgings are considered in some detail. KF

New Alloys in Railway Rolling Stock. Fred H. Colvin. *American Machinist*, September 12, 1929, pages 449–450.

Discusses use of aluminum forgings, and steel alloyed with chromium, nickel, vanadium, manganese or other metals in wheels and locomotive parts for strength and saving in weight. KF

New Steels for Internal-Combustion Engines. R. Schmidt. *Engineering Progress*, September 1929, pages 237–238.

Chromium-vanadium steels which have greater hardening range and greater depth of penetration of hardening than the nickel-chromium steels are used for the large parts of internal-combustion engines. They can often be used in the annealed state and have excellent wearing qualities. Molybdenum alloys which have high tensile strength and great hardening range are used where strength is desired. Chromium-silicon steels which retain their hardness at high temperatures and are proof against scaling are used for valve cones. Charts showing tensile properties of these alloy steels are given. KF

Light Alloys in Aircraft. E. F. Warner. *Aviation*, September 1929, pages 511–513.

The author assembles the main statements from the four metallurgical papers presented in Cleveland at the session of the Society of Automotive Engineers during the Air-race week: E. H. Dix summerized the present state of Al-alloys including the occurrence and protection of corrosion. The paper of G. D. Welty dealt with light alloys in engine design and C. B. Sawyer largely pertained in his lecture to the properties and industrial potentialities of Be. In the final paper R. M. Mock spoke on "Welding in Aircraft Construction," concerning himself almost exclusively with the welding of steel, making only passing mention of the possibilities of welding Al and its alloys. EF

Wheels of Light Weight Made of Electron. (Leichte Räder aus Elektron.) *Philòdisk. Deutsche Motorzeitschrift*, August 1929, pages 398–402.

The advantages of wheels made of electron (sp. gr. 1.8) are outlined and the experiences during the commercial uses in Germany are described. The generally applied alloys are: AZF cast with 17–20 kg./mm.^{2} and 4–6% elongation; and AZM rolled with 28–32 kg./mm.^{2} tensile strength and 12–14% elongation. EF

A New Type of Machine Bronze. M. G. Corson. *Metal Industry, N. Y.*, June 1929, pages 278–279.

Describes the development of low tin bearing bronzes, which can be hot-worked, forged and extruded. VSP

Effect of Temperatures Attained in Overhead Electric Transmission Cables. A. v Zeerleder & P. Bourgeois. Paper before Institute of Metals, September 1929, 7 pages.

The increases of temperature produced by a current of electricity in transmission cables made, respectively, of copper, pure aluminum, steel-aluminum and Aldrey were measured. Cables consisting of these materials were submitted to temperatures lower than the usual annealing temperatures for periods ranging over several months up to one year, and the effect on the mechanical properties was examined. It was found that Aldrey is not affected by temperatures which will seriously diminish the tensile strength of copper. Cables consisting of aluminum alloys having undergone previously an appropriate heat-treatment—such as Aldrey—are thus able, in spite of their lower electrical conductivity, to be loaded with higher current densities than copper cables, without danger of slow annealing. AEH

Notes on Wire for Mining Ropes. A. T. Adam. Paper before Iron and Steel Institute, September 1929, 20 pages.

The conditions to which the wires in mining ropes are subjected in service are briefly summarized, and the effects of water, bending and direct kinetic stresses on the wire are discussed. The effects of corrosion are not considered. A discussion on the significance of endurance and fatigue tests on cold-worked steel follows, and an argument is submitted in support of the view that since rope wires are inevitably stressed beyond the limiting safe range for repeated stresses their capacity for withstanding overloads and deformation for a sufficiently lengthy period is more important than their fatigue limit as determined by lengthy endurance tests on a basis of several million cycles of stress. It is also argued that the internally stressed condition of cold-worked metals, by insuring a wider distribution of stress, increases the state of what Professor Haigh calls "primary hysteresis" and is, therefore, a safeguard against stress concentration due either to discontinuities in the metal itself or to the general service conditions. General tests on wire point to a stage in drawing, varying from 50–80% reduction of area, according to the various factors influencing drawing, which represents the point of greatest efficiency. The need for a simple test by which this point may be readily determined for any material, is mentioned. The conclusion is drawn that the lowest carbon steels capable of giving the tensile strength desired in the finished wire without overdrawing are to be preferred for mining rope wire and, finally, it is claimed that the conclusions are entirely supported by practical experience. AEH

HEAT TREATMENT

Regulated Control in Heat-Treating Aluminum-Alloy Castings. *American Machinist*, September 5, 1929, page 403.

Briefly states order of procedure in heat-treating aluminum alloy castings at Fairfield Plant of Aluminum Alloy Company of America. KF

Heat-Treatment of Airplane Parts. R. E. Johnstone *American Machinist*, September 5, 1929, pages 389–390.

The Seattle plant of the Boeing Airplane Company heat-treats all steel parts used, in electric furnaces, thermostatically controlled. Chrome-molybdenum parts are treated to a maximum heat of 1625° F. and nickel steel parts to 1500° F. Duration of treatment depends on size and thickness of the part and the type of metal. After heating, the parts are quenched in oil and replaced in the furnace for a secondary heating with the temperature considerably less than the maximum for the original heat treatment. All aluminum alloy parts are heated in tanks containing a solution of potassium and sodium nitrates which is kept at a maximum temperature of 950° F. The duration of heat treatment varies from 9 min. for metal 0.0179 in. thick to 28 min. for metal 0.2043 in. thick. After heating material is quenched in water. KF

Influence of Heat-Treatment on Gray Cast Iron. (Influence du traitement thermique sur la foute grise.) Godefroid. *Revue fonderie moderne*, July 25, 1929, pages 293–302.

The article gives the results of investigations on the heat-treatment of different gray cast irons. In the first part the influence of heat-treatment after quenching on structure and mechanical properties, as shown by Brinell hardness, is dealt with. Further, the influence of some alloying elements as silicon, nickel, manganese and chromium was investigated. A treatment at too high a temperature or for too long a time impairs the physical properties. A temperature of about 600° C. should not be exceeded. GN

Hardening

Investigations on Hardened Steel. (Prooning av härdat stal. II. A. Lundgren. *Jern Kontorets Annaler*, August 1929, pages 367–374.

The author investigated the influence of annealing time and velocity in cooling down on the physical properties of hardened steel. Four carbon steels were examined. (1) Three steels were quenched in oil from 755 to 760° C., drawn at 200 and 300° C. for 15 minutes and thereafter cooled down in air or water or in the oil bath either with a temperature drop of 10° C. per 2–4 minutes. The results are: The influences of speed in cooling down is especially to be seen after drawing at 300° C. Cooling in air gives the highest bending strength. The bending strength of air or oil cooled samples is much smaller; decreases up to 40%. The influence of cooling speed cannot be observed in examining the hardness and impact stress. Aging effects were studied with oil and water cooled specimens, drawn at 300° C. (2) Likewise the influence of the time of drawing was investigated with these carbon steels, quenched in oil from 760 or 800° C. tempered at 150, 200 and 300° C. for different times. The bending strength and impact strength increase with the time of drawing, the hardness decreases. Drawing for ten minutes at 150 and 200° C. results in a higher bending strength (30–50 kg./mm.^{2} increase) than drawing for 3 minutes. Drawing at 157° C. for 60 minutes results in a higher hardness and bending strength than drawing at 200° C for 3 minutes. GN

Annealing

Technological Studies on Bright Annealing of Steel in the Electric Furnace. (Technologische Studien über das Blankglühen von Stahl im elektrischen Ofen.) A. Pomp & L. Walker. *Stahl und Eisen*, September 12, 1929, pages 1329–1334.

Paper at the 19th meeting of the rolling mill committee of the "Verein deutscher Eisenhütteute," May 28, 1929. See *Mitteilungen Kaiser-Wilhelm Institut für Eisenforschung*, **2**, 15–30(1929).

The authors describe a 25 K. W. electric furnace and its mode of operation as used in the "Kaiser-Wilhelm Institut für Eisenforschung" for annealing steels. An essential improvement of the properties by annealing in such a furnace, compared with a coal-fired pot annealing furnace, must be contributed to a better distribution of heat and a better regulation of temperature and time of annealing. In case hydrogen is used as a protective medium against oxidation an improvement was also to be found, but only with steels, the carbon content of which is not too low. A decarburization could not be noticed up to 700° C. in using hydrogen as protective gas. Annealing of transformer and dynamo materials in a hydrogen atmosphere in the electric furnace yielded an essential improvement of the values of energy losses (in watts) in comparison with the furnaces in the plants generally used. GN

Annealing Steel Sheets in Continuous Gas-Fired Kilns. J B. Nealy. *Transactions American Society for Steel Treating*, September 1929, pages 429–434.

The increasing use of long furnaces or kilns which are automatic and continuous in operation, for heat-treating steels is resulting in improvement in their design and control. Two modern gas-fired kilns used in white and black annealing are described. ESC

Effect of Annealng on the Grain Structure of Extremely Hard Rolled Steel Ribbon. N. P. Goss. *Transactions American Society for Steel Treating*, September 1929, pages 405–414.

Observations are given which show that when a hard rolled steel ribbon of low carbon content was annealed between 1200° F. and the upper critical temperature a new orientation of grains developed, whereas when such annealing was carried out at a temperature below 1200° F. no change in orientation resulted but instead large grains grew which showed random orientation. The new orientation as in the first case is accounted for through the formation of twinned crystals in which the (2 1 1) planes are twinning planes. ESC

Case Hardening

Surface Hardening of Steel by Nitrogen. H. W. McQuaid. *Mechanical Engineering*, September 1929, pages 967–971.

Paper at the meeting of the Chicago Section of the A. S. M. E. March 18, 1929. The nitriding process and the steels best applied are described, and the advantages in comparison with case-hardened steels are shown. Carbon steels in a sorbitic condition are best suited for nitriding. Speeding up of the ammonia circulation accelerates the process. Description of electrically heated furnaces with automatic temperature control. Nitriding process to be successful should be run at high temperatures of about 1200° F., which decreases the time of nitriding. Applications of nitrided steels are given, which previously were excluded from many fields due to high costs. GN

Economical Re-Use of Solid Carburizing Materials. H. B. Knowlton. *Transactions American Society for Steel Treating*, October 1929, pages 607–625.

Includes discussion. Paper presented at the Eleventh Annual Convention, American Society for Steel Treating, Cleveland, September 9, 1929. An investigation of the re-use of carburizing materials with particular reference to the amount of new material which should be added after each carburizing run in order to maintain a constant volume and a constant activity of carburizing compound. Methods of handling which minimize mechanical losses, and methods of screening and mixing which assure a uniform dustless material are described. An analysis is given of the changes in composition which may take place during the use of a carburizing compound. A method for determining the limits of composition for a mixture of old and new material is described. It is also shown that by practical application of the principles given in this paper a large saving in cost has been effected. ESC

The Constitution of Steel and Cast Iron, Section II, Part XI. F. T. Sisco. *Transactions American Society for Steel Treating*, September 1929, pages 435–451.

This installment, the eleventh of a series, takes up the heat treatment of carburized steel and its effect upon the structure Illustrated by representative micrographs, the discussion of heat treatment includes the effect of cooling slowly from the carburizing temperature, quenching directly from the box, quenching to harden the case and regeneration quenching to harden the case and refine the core. Following this discussion the surface hardening of steel is briefly described. Included in this are the operations of cyaniding, pack hardening and nitriding. The installment closes with a brief view of normal and abnormal carburizing steels. ESC

Aging

Age Hardening of Aluminum Alloys. *Nature*, May 18, 1929, page 780.

On prolonged annealing of aluminium alloys containing copper and /or magnesium silicide occurs. The same changes occur during the earlier periods of aging. Crystals in the aged material are in a disturbed state; this distortion of the space lattice is probably due to this precipitation from the supersaturated solid solution. The succeeding coagulation of the atoms or molecules into minute crystallites gradually relieves the distortion of the lattice.

Quenching

Hot Solutions for Quenching Steels. H. J. French & T. E. Hamill. *American Machinist*, September 5, 1929, pages 413–414.

Abstract of paper presented at A. S. S. T. meeting in Cleveland, September 9–13. Describes experiments which developed that 5% solutions of sodium chloride and of sodium hydroxide at various temperatures provide a graded set of cooling rates from those of water and the more rapid aqueous solutions at atmospheric temperature to those of the customary oils. States certain disadvantages accompanying their use such as their corrosive nature, undesirability of maintaining rapid cooling at low temperatures in hardening some steels, and difficulty of handling these solutions industrially. Includes a table giving results of the experiments. KF

Behavior of Carbon Tool Steel on Quenching. G. V. Luerssen. *American Machinist*, September 5, 1929, pages 407–408.

Abstract of paper presented at A. S. S. T. meetings in Cleveland, September 9–13. A general discussion of the use of carbon steel for tools and the variations in its behavior. Shows how uniformity in hardness penetration and quenching range are necessary to obtain uniformity in final tools. KF

JOINING OF METALS AND ALLOYS

Welding and Cutting

Welding Wire Experience at Watertown Arsenal. T. B. Rose. *Wire & Wire Products*, October 1929, pages 344–345.

Excerpts from a paper read before the September meeting of the American Welding Society, having to do only with data on welding wire. MBR

How to Weld Galvanized Iron. *Brass World*, August 1929, pages 194–195.

An abstract. The procedure used in joining galvanized iron parts with steel or bronze welding rod is outlined. Several illustrations are included. WHB

WORKING OF METALS & ALLOYS

Forging

The Effect of Reduction from Ingot to Forging in Steel Forging. L. H. Fry. *Advance copy for Proc. Am. Soc. for Testing Materials*, 29 (2), (1929), 11 pages.

Condensed account of cooperative tests by Bethlehem, Carnegie, Standard Steel and Camden Forge which indicate that greater reduction than 3 to 1 between ingot and forging has no special advantage. Smaller forgings respond more readily to heat treatment, and this factor is more potent than the degree of reduction. It is concluded that when forgings themselves are purchased, the purchaser is protected by the specifications for the forgings themselves, and no stipulation as to degree of reduction need be incorporated, leaving the maker to adapt the size of the ingot to the size of the forgings. For billets to be worked up into forgings, a stipulation of a 3 to 1 reduction might well be retained. Changes in A. S. T. M specifications A 17–21 were recommended as a result of the work. HWG

Melting and Refining

Production of Electric Steel for Castings. George Batty. Paper presented at Eleventh Annual Convention, American Society for Steel Treating, Cleveland, September 10, 1929.

Two sharply differentiated methods of melting and finishing a heat of steel are considered in this paper. These are applicable to both carbon and alloy steels for castings. It is recommended that in the ordinary conditions in a steel where scrap is contaminated by adherent sand a definite boil of the bath be secured with some inevitable elimination of carbon in order that finely divided non-metallics may be precipitated. It is affirmed that to "kill off" the final traces of free and active oxide of iron in the bath with ferro-silicon is neither sound nor desirable practice. ESC

Making of High Manganese Steel in Electric Furnaces. (**L'acier a fort teneur de manganese au four electrique.**) *Journal du four electrique*, August 1929, pages 269–270.

A method for making Hadfield steel is described. Melt under lime slag (2% of the weight of the charge) to which scale or ore is added to bring C down to about 0.01%. Build white slag by adding CaO 100 parts, CaF_2 40 parts, coke 15 parts. When thoroughly melted ferro chrome is added and the slag reduced. A considerable care is necessary for production of clean castings. JDG

Melting Practice for Three Types of Electric Steel. H. P. Rassbach. Paper presented at Eleventh Annual Convention, American Society for Steel Treating, Cleveland, September 10, 1929.

The melting practice for three types of electric furnace steel is described. A carbon tool steel, chromium vanadium steel and a high speed steel are discussed specifically. Proper selection of scrap for each charge is discussed. Slag conditions at various stages of the heat are described and slag and metal analyses given. Emphasis is placed upon the importance of deoxidizing the slag to a high degree. ESC

Diffusion of Iron Oxide from Slag to Metal in the Open-Hearth Process. C. H. Herty, Jr. *Mining and Metallurgy*, August 1929, page 389.

Abstract of technical publication 229 of the American Institute of Mining and Metallurgical Engineers. Discusses the theory of diffusion of FeO from slag to metal. Gives a number of illustrations and examples showing its practical application VSP

The Poling of Copper. P. Siebe. *Metal Industry, London*, July 5, 1929, pages 3–7.

Gives results of experiments. Blister copper, copper scraps, etc., containing about 95% of copper is melted in reverberatory furnace. Molten copper is oxidized by means of air. Impurities volatilize and slag is skimmed off. Green wood is thrust into molten metal to eliminate oxygen by "poling." Describes the fracture of button samples and macro-structure of slabs, density and gas absorption, electrical conductivity and overpoling of copper. Includes numerous tables and illustrations. VSP

Byers New Process for Wrought Iron. James Aston. *Iron Age*, August 8, 1929, pages 341–344.

To be presented at Cleveland meeting of the American Institute of Mining and Metallurgical Engineers. States that any improvements on present-day method of hand puddling of wrought iron must improve the product and reduce cost. Pilot plant at Warren, Ohio, produces 200 tons daily. Author's method is to pour molten mild steel on molten slag which below fusion point of the steel; the ratio of the slag to steel being from 6 or 8 to 1. During pouring there is a boil due to evolution of gas in solution. Slag is poured off and a spongy solidified mass of metal remains. The metal is worked into a bloom for rolling. It is expected to enlarge the wrought iron market owing to its lower cost and greater tonnage. VSP

Machining

Machinability of Metals. *American Machinist*, Sept. 5, 1929, page 415.

Abstract of paper by O. W. Boston presented at A. S. S. T meetings in Cleveland, Sept. 9–13. Presents tables giving results of machinability tests made on steel and non-ferrous metals at University of Michigan. KF

Casting

The Reduction of Shrinkage Cavities and Vacuum Melting. W. J. P. Rohn. Paper before Institute of Metals, September 1929, 12 pages.

Shrinkage cavities may be diminished if care is taken that the solidification of an ingot starts from its bottom end and advances gradually to the top end. This control of the freezing process is not obtainable by using sand molds or cast iron molds, but can be approximated to a certain extent with water-cooled copper molds. The special construction of such molds, to be used in connection with vacuum melting furnaces, is described, and some details given regarding vacuum melting. Shrinkage cavities, it is shown, may be totally avoided if melting and freezing are performed in an electrically heated melting furnace in a crucible of the shape of the finished ingot, and, after melting and refining is completed, the current is cut off gradually from the bottom with a well-controlled speed. Illustrations of cross sections of ingots so produced and of their crystal structure are given. AEH

Cold Working

On the Distribution of Hardness Produced by Cold Working. W. P. Sykes & A. C. Ellsworth. Paper presented at Eleventh Annual Convention, American Society for Steel Treating, Cleveland, September 10, 1929.

This paper presents a preliminary study of the progress of hardening throughout the section produced by cold working. Three metals are observed. That of highest original hardness increases least in hardness by reason of a 25% reduction by cold swaging. Most of this increase in hardness occurs in the first 3% reduction. The smaller the original diameter of the swaged rod the less the reduction required to produce uniform hardness throughout. Uniform hardness is more rapidly developed in a hard material than a soft one. In any analysis of hardness distribution throughout the section of a worked metal it is necessary to consider the heat developed during the process of deformation. ESC

The Constitution of Steel and Cast Iron. F. T. Sisco. Section II, Part XII, *Transactions American Society for Steel Treating*, October 1929, pages 626–639.

The twelfth installment of this series. A study of the effect of cold working on the properties of steel, ultimate strength hardness, elongation, torsion and bend. There is a similarity in the change of properties due to cold working which corresponds to that due to heat treating, in that strength and hardness increases and ductility decreases. It might be said that energy absorbed yields corresponding results whether applied in the form of mechanical work or heat. Plastic flow and the mechanism of slip are discussed. Hardening by cold work is explained as due to slip interference. ESC

Drawing and Stamping

A Study of the Causes of Cuppy Wire. W. E. Remmers. *Wire & Wire Products*, October 1929, pages 333–335.

Paper presented at the fall meeting, Institute of Metals, Division of American Institute of Mining & Metallurgical Engineers. A definite relationship exists between the die angle and the oxygen content of copper wire rod, which determines whether or not the rod can be drawn into good or cuppy wire. This relationship can be altered by various factors, smooth-curve contour dies and large reductions per die acting to give a better product, while relieved dies, reversals of drawing direction and many reductions tend to make a product of lower quality. MBR

Pickling

The Test of Acid in the Pickling Plant. (**Säureprüfung im Beizereibetrieb.**) F. Eisenkolb. *Stahl und Eisen*, August 8, 1929, pages 1162–1164.

The advantages and disadvantages of H_2SO_4 and HCl, respectively, as means of pickling are discussed. Arsenic is the most disadvantageous impurity. The methods for the determination of free acid in pickling baths are described. GN

DEFECTS

The Occurrence of Failures with Hard-Soldering of Steel. (**Das Auftreten von Brüchen beim Hartlöten von Stahl.**) W. Riede. *Stahl und Eisen*, August 8, 1929, pages 1161–1162.

Cracks are often to be observed in plunging steel tubes of small wall thickness in a molten bath of brass for hard soldering. The origin of these cracks was found in a local recrystallization of the cold worked material and when the bath temperature exceeded 1100° C. Cracks could not be observed in normal material. GN

Critical Investigations of Steel Castings. (**L'examen critique des moulages d'acier.**) G. F. Gillot. *Revue fonderie moderne*, July 25, 1929, pages 303–310.

The failures of steel castings and the means used to determine these failures are described. They can be brought out by macroscopic, microscopic and X-ray examinations. The problem of pipes and cavities is discussed. GN

Steel which Is Sound in Blooming. Joseph R. Miller. *Iron Age*, August 15, 1929, pages 399–400.

The burden of seams and cracks in steel has been shifted to the steel maker. Author describes his own series of tests to compare different compositions and suitable temperatures for each. Open-hearth free cutting steel (added sulphur) rolled much better if manganese was raised 1$^1/_4$ % Formerly manganese content was around 0 60–0 80 % Steel free from oxides rolls better. VSP

CHEMICAL ANALYSIS

Rapid Method for Dissolving High Chromium Steels for the Determination of Sulphur. B. S. Evans. *Analyst*, May 1929, pages 286–287.

The solution of samples of stainless steels is effected by means of hydrochloric acid, oxidation by means of nitric acid being effected subsequently. A dimensioned sketch of the apparatus is given.

HISTORICAL AND BIOGRAPHICAL

The Story of Early Metallurgy. Part 5.—Early Currency. R. T. Rolfe. *Metal Industry*, London, June 21, 1929, pages 605–607.

Concluding article. Traces the growth of gold, silver, copper, bronze and iron currency to Greek times and Cretan culture. VSP

INSPECTION

Proposed Control Methods for Small Heat Treatment Plants. Welton J. Crook. *Transactions American Society for Steel Treating*, September 1929, pages 415–428.

A hardness testing instrument and a hardening furnace are shown by the author to be adequate equipment to obtain considerable information about its raw materials and products. By the use of hardness values obtained therewith it is possible to closely estimate the tensile strength of steel with the help of conversion formulae. These values of tensile strength will be sufficient for engineering purposes. Regeneration tests and macro-etching are discussed. ESC

GASES IN METALS

The Gas Content, Crystal Structure and Hydrogen Absorption of Sputtered Nickel Films. L. R. Ingersoll & J. D. Hanawalt. *Physical Review*, Sept. 15, 1929, pages 972–977.

With the use of a special deposition tube which permitted the withdrawal of the cathode without altering vacuum conditions, films of nickel have been sputtered in residual atmospheres of hydrogen, helium, nitrogen and argon, and their gas content investigated. This is large, though in general not reaching one molecule per atom of metal. Upon heating, the gas is emitted copiously at 300–400° C., which is just the baking temperature range for which such films become magnetic and also much better conducting. As permeability is supposed to be a rapid inverse function of atomic distance it seems probable that the gas, by keeping the atoms apart, is primarily responsible for the abnormal magnetic and other properties of such films, although it is impossible to separate this effect entirely from the factor crystal structure. Resistance measurements made during baking on a series of sputtered and evaporated films indicate that the evaporated film contains much less gas than the sputtered even when produced in the same gas pressure. This may be explained on the basis of the excitation or activation of the gas during the sputtering process, which promotes its occlusion—sometimes as a compound with the metal. When care is taken to avoid undue heating during sputtering the film may be amorphous, or, when produced in hydrogen or nitrogen, may be crystalline with a lattice somewhat different from the normal, pointing to the existence of nickel hydrides and nitrides produced in the activated gas in sputtering. Definite evidence of helium or argon compounds is lacking. These films also possess to a remarkable extent the ability to absorb hydrogen when a certain critical temperature is exceeded. This temperature depends on the previous heat treatment given the film and may be as low as 100° C. The amount of hydrogen absorbed is many times that required for a monomolecular layer for the superficial area of film. The hydrogen shows no effect on the crystal lattice and as the higher the baking temperature the less the absorption, the gas is supposed not to enter the crystal structure but to be located in the inter-crystal region. This may be typical of gas absorption in general, excepting such cases as palladium-hydrogen.

Conditions Necessary for Blistering of Metal during Processing. Dr. Anson Hayes. Paper presented before Eleventh Annual Convention, American Society for Steel Treating, Cleveland, September 9, 1929.

This paper points out two facts which have not generally been recognized in considering the causes of blistering of sheet metal. The first one is that the pressure required to raise a blister is inversely proportional to the radius of curvature of the lamination in the sheet. Laminations at distances greater than 0.025 centimeter (10^{-2} inches) must have radii of curvature greater than 0.5 centimeter for blistering to occur. The second is that in the pickling process the pressures which are responsible for the penetration of hydrogen during the pickling process are due to the surface tension of the pickle liquor during the time that the bubbles of hydrogen are quite small. Pressures which may be developed by the reaction $FeO + C \longrightarrow CO + Fe$ are very large, and blisters from smaller laminations at greater distances from the surface may result in annealing. ESC

Diffusion of the Gases through Metals. (Recherches sur a diffusion des gaz a travers les metaux.) V. Lomabrd. *Revue de Metallurgie*, July 1929, pages 343–350.

A study of H_2, N_2, Ar and He diffusion through Ni, Fe and Pt. An apparatus for determination of gas penetration through disks of metals at different temperatures is described. Most of the work was conducted on Ni. The speed of diffusion under identical temperatures and pressures does not change with time. For a given temperature the speed of diffusion is the same independently from the temperature being obtained by cooling down or heating up. The penetrability of the sheets of the same thickness varies within 20% presumably on account of difference in structure. The presence in H_2 of traces of O_2 and moisture does not affect the rate of penetration. The speed of diffusion is proportional to the square root of the pressure. Temperature influence can be expressed in the range studied 350–750° as an exponental function. Penetration is inversely proportional to the thickness of specimens. A formula embodying these factors is given and its constants determined. Diffusion of H_2 in combination with gases inert to it is proportional to the square root of its partial pressure. The permeability of two adjoining sheets is equal to the penetrability of the sheet the thickness of which is the sum of the thicknesses of the former. The same laws apply to Fe and Pt. Some preliminary tests show that the penetration of Ni by N_2 and Ar at about 500° is about 100 times less than that of H_2 while the penetration of He must be much faster. JDG

Gas Solubilities in Melts of Pure Aluminum and of an Aluminum Alloy. (Gaslöslichkeit in Schmelzen von Reinaluminium and einer Aluminiumlegierung.) W. Claus, S. Priesemeister & E. Kalaehne. *Zeitschrift für Metallkunde*, August 1929, pages 268–270.

The paper deals with investigations concerning the solubility of gases in melts of pure aluminum and of the American alloy (8% Cu, 92% Al) by gasification with nitrogen, oxygen, carbon monoxide, carbon dioxide, sulphur dioxide, hydrogen, illuminating-gas, methane, ethylene and superheated water vapor. The interesting data and the results of the experiments which were carried out at temperatures of 700 and 800° C., are given in 2 tables. The importance of melting Al-alloys in pot furnaces is demonstrated. If the application of crucibles cannot be avoided, only those fuels should be employed which produce the smallest amount of water-vapor as it exhibited very bad influences in form of its decomposition products—hydrogen and oxygen. Some remarks are made on the alloy "Y" containing 1.5% Mg, 2% Ni, 4% Cu and 92.5% Al. EF

Effect of Nitrogen in Iron and Steel. V. N. Svechnicov. Part II. *Blast Furnace & Steel Plant*, August 1929, pages 1165–1167, 1173.

Translated from the Russian by I. P. Tolmachoff. Deals with source of nitrogen content in steel with particular reference to the Bessemer process. Gives numerical results obtained in several experiments. It has been found that long blowing and high wind pressure increase nitrogen content. Amount of nitrogen in pig-iron, high in silicon increases regularly with rising temperature. With pig-iron, high in manganese, it increases very rapidly below 1290° C. Between 1290 and 1440° C. there is a considerable lag in absorption of nitrogen. Addition of aluminum had no apparent effect on nitrogen content. MS

FURNACES & FUELS

Application of Pulverized Coal to Metallurgical Furnaces. W. O Renkin. *Iron & Steel Engineer*, August 1929, pages 465–74.

Approximately 200 pulverized coal plants have been installed in the American iron and steel industry. They supply fuel to approximately 2500 furnaces used for puddling, forging, continuous heating, sheet and pair, open and box annealing and malleable iron melting furnaces. The paper is divided under 9 headings and useful information regarding actual results are stressed, rather than description of equipment. The following advantages of pulverized coal firing are given: (1) reduction in fuel per ton of output; (2) increased production; (3) ability to use low grade coal when price warrants or other conditions require; (4) ability to secure any type of flame from highly oxidizing to intensely reducing; (5) lower furnace maintenance due to simpler construction and the relatively softer heat; (6) easy temperature control; (7) reduced cost per ton of output; (8) reduction in metal loss; (9) ability to concentrate fuel preparation at the most economical point; and (10) reliability of fuel supply. WHB

Application of Pulverized Coal to Metallurgical Furnaces. H. W. Hollands & E. C. Lowndes. *Foundry Trade Journal*, July 18, 1929, pages 41–45.

Paper read before the International Foundrymen's Congress. Includes discussion. Considers the "bin-and-feeder" and the "direct-fired" systems, and discusses the advantages of the former and disadvantages of the latter. Coal for heating and melting purposes should be dried to less than 1% and pulverized, so that 98% passes through 100-mesh screen. The ash content should be low. The advantages of pulverized coal are as follows: (1) cheaper coal may be used; (2) flexibility; (3) time of heating reduced; (4) banking starting and stopping losses reduced; (5) consumption of coal is reduced from 25 to 50%. Gives results of actual experiences with billet, plate heating and puddling furnaces, using pulverized fuel. VSP

Pulverized Coal in Steel Furnaces. William O. Renkin. *Iron Age*, July 18, 1929, pages 155–156.

Abstract of a paper read before the Association of Iron and Steel Electrical Engineers, June 20, 1929. Gives historical sketch of the use of pulverized coal in metallurgical work. Types of furnaces using pulverized fuel, such as: iron blast furnaces, air furnaces, open-hearth furnaces, reheating furnaces and annealing furnaces. Type of equipment required. Fuel costs per ton of product. Advantages of pulverized coal firing. General information and comparative fuel costs. VSP

Principal Features of Operation of the Furnaces Constructed Accordingly to the Hydraulic Theory of Furnace Construction. (Principes de fonctionnement d'etuves construites rationnellement du points de vue hydraulique.) W E. Groume-Grjimailo. Translated by L. Dlougatch. *Revue de Metallurgie*, July 1929, pages 351–357.

An example of application of the hydraulic theory of furnace construction to drying ovens. JDG

Circulation of the Flames in the Heating Chamber of the Furnaces Guarantees Uniform Temperature. (Fours a circulation des flammes au laboratoire guarantissant l'obtention d'une temperature uniforme.) W. E. Groume-Grjimailo. Translated by L. Dlougatch. *Revue de Metallurgie*, July 1929, pages 358–363.

A description of the application of the hydraulic theory of furnace construction to open flame heating furnaces. To equalize the temperature at the bottom and under the roof the flame is introduced in the middle of the bottom and hot gases, partially mixing with cooler combustion product, raise to the top and descend along the walls to the bottom where they are removed. The flame can be introduced at the sides of the bottom and removed at the center of it. A continuous circulation of gases of approximately the same temperature produced by this arrangement equalizes the top and bottom temperatures within 10 degrees in furnaces 6 meters high. The uniformity of the temperature is specially pronounced above 600°. An enlargement of the usual furnace dimensions is advocated. A calcining furnace, a tunnel porcelain burning furnace, a heat treating furnace for gun forgings and a pot annealing furnace are described. JDG

Salt Baths for the Hardening of High Speed Steel. Bengt Kjerrman. *Transactions American Society for Steel Treating*, September 1929, pages 393–398.

This paper reports the results of a series of experiments on salt bath and salt bath containers used for heating high speed steel for hardening comparisons of crucible materials, salt used, and combinations of the two are made. It is found that a chamotte crucible as the container for barium chloride to which ferrosilicon is added eliminates decarburization of high speed steel and increases the life of the crucible about 4.5 times that obtained with a molded silica crucible. ESC

A New Furnace for Heat Treating High Speed Steel. Wesley B. Hall. *Transactions American Society for Steel Treating*, September 1929, pages 399–404.

A new electric salt bath furnace for heat treating high speed steel is described. The bath is heated by current flow through the molten salt from an electrode to the pot wall. The simplicity of this construction permits lower cost of operation, longer life and higher temperatures than with the usual resistance heaters. A transformer is required for each pot to supply the low voltage and high current needed. The construction, operation, electrical characteristics and power consumption of these furnaces are discussed. ESC

The Electric Arc Furnace in the Brass Foundry. J. B. Meier. *Metal Industry*, New York, June 1929, pages 282–283.

Conclusion of article previously published in *Metal Industry*, May 1929. Subdivides the cost of melting into electric power, labor electrodes, crucibles, lining, fuel costs and metal losses, and briefly discusses each. VSP

Progress in Electric Furnaces for Non-Ferrous Metals. M. Tama, Paper before Institute of Metals, September 1929, 8 pages.

New induction furnaces of large capacity are described. They have been developed for high-melting point alloys such as nickel-brass and phosphor-bronze. Thirty-four electric annealing furnaces of the resistor type are shown to be in successful operation in a large metallurgical plant. The advantages of the use of electricity both for melting and annealing non-ferrous metals are emphasized. Recent improvements in refractory linings for melting copper alloys, devices for charging swarf into electric furnaces, and various types of electric bright annealing furnaces are described. AEH

The Industries Using Electric Furnaces in Italy. (Les industries du four electrique en Italie.) *Journal du four electrique*, August 1929, pages 261–262.

A brief sketch of Italian industries using electric furnaces. JDG

EFFECTS OF ELEMENTS ON METALS AND ALLOYS

Report of Research Committee on the Effect of Tin and Arsenic on High Speed Tool Steel. *Advance copy for Proc. Am. Soc. for Testing Materials* 29 (1), (1929), 5 pages.

Two heats of high speed steel of around 0.66% C, 17.35% W, 3.75% Cr, 0.95% Va, one containing 0.45% Sn, the other 0.51% As, were made up and compared with stock high speed steel (18% W) as milling cutters, cutting S. A. E. 3245 Cr Ni steel heat-treated to 241 Brinell. The cutters themselves were preheated to 1700° F., heated to 2350° F., oil-quenched and drawn 30 minutes in oil at 1125° F. Under the chosen test conditions the stock cutter made 20 cuts without being too dull for further use. The tin steel was unusable after an average of 17 and the arsenic steel after an average of 19. Four tests were made of each. Drilling tests could not be made as both the Sn and As steels were so brittle as to be worthless, and broke readily in service. In the annealed condition, although the hardness was normal, bars of each steel $24'' \times 1^{1}/_{16}''$ broke in several pieces when dropped 4 feet to a concrete floor. The ingots did not flow as readily in hammer-cogging as normal high speed. In making the crucible melts, only about 30% of the tin and 20% of the arsenic charged, were lost. Since obvious brittleness and a perceptible decrease in cutting properties were shown with about half a percent of Sn or As the committee will continue work with lower percentages. Much present-day tungsten ore contains considerable percentages of these impurities. The impurity content of ores from different localities is discussed. HWG

Malleable Cast Iron (La Fonte Malléable). M. Godefroid. *Revue fonderie moderne*, June 25, 1929, pages 243–251.

The author gives information on the composition and method of manufacture of different malleable irons. The influence of some alloying elements, as chromium, silicon, nickel, copper on the temper process was investigated. GN

REFRACTORIES & FURNACE MATERIALS

Relining of Blast Furnaces without Blowing Them Out. (Refection des hauts fourneaux sans mise hors feu.) A. Cousin. *Revue de Metallurgie*, August 1929, pages 395–400.

The practice of Societe Cockerille plants shows that the lining of the belly wears out first when boshes, hearth and the top are still in good condition, the first of them being protected by a limey coating deposited during the campaign of the furnace. If the jacketing of the furnace is strong enough to support the empty stack, the charge is blown down to the level of the boshes, a large opening is made about two meters above the level of the stock and the top opened. The draft produced skulls the top of the stock and cools the shaft so that in about 24 hours the masons can work comfortably inside. Many relinings of 250 tons-a-day furnaces following this method averaged 8–12 days for completion. The efficiency of the lining as a whole was unimpaired. A detailed description of the procedure is given. JDG

Improving of Refractory Lining of Heat Treating Furnaces for High Temperature Annealing of Steel Castings. William J. Merten. *Transactions American Society for Steel Treating*, October 1929, pages 600–606.

Includes discussion. Paper presented before the Eleventh Annual Convention, American Society for Steel Treating, Cleveland, September 9, 1929. The use of a highly refractory glaze as a protective coating to be applied on ordinary firebrick furnace wall surfaces for high temperature annealing of large section steel castings or forgings is advocated. The beneficial effect upon furnace linings is pointed out. A method of coating steel castings to prevent scaling at high temperatures is recommended. ESC

INSTRUMENTS & CONTROLLERS

An Improved Differential-Dilatometer. Max Haas & Denzo Uno. Paper before Institute of Metals, September 1929, 5 pages.

The author describes a method for improving the accuracy of Chevenard's optical differential dilatometer by mounting the apparatus on a triangular rail and by using one dilatometer tube instead of two and by replacing the spring which holds the mirror by a magnet coil arrangement. Modifications for working in any special atmosphere and for sketching have also been made. AEH

PLANTS AND LABORATORIES

Uses Universal Heat-Treating Unit. F. W. Manker. *Iron Age*, September 12, 1929, pages 663–666.

Describes three furnaces with pushers and pullers interconnected with time controls, forming a continuous and automatic outfit. These have been put in operation by the Packard Motor Co. Gives dimensions and method of operation. VSP

Studebaker Methods of Forging and Heat-Treating. Frank J. Oliver, Jr. *American Machinist*, Sept. 5, 1929, pages 383–388.

Describes in considerable detail the layout in the forge shop at Studebaker plant, South Bend, Indiana. Manufacture of several parts is followed through the forging and heat treating operations. Emphasis is on the arrangement of equipment which is planned to minimize handling of material. KF

MISCELLANEOUS

A Proposal for Organization of Research Conducted on Characteristics of Alloys at Elevated Temperatures. (Project d'organization general des recherches sur la tenue a chaud des alliages.) Andre Michel. *Revue de Metallurgie*, August 1929, pages 447–450.

An appeal for better cooperation in industrial research in France with the outline of problems needing attention. JDG

The Development of Electrochemical Industries. (Le developpement des industries electrochimiques.) *Journal du four electrique*, August 1929, pages 257–259.

A brief survey of the present state of electrochemical industries of the world. JDG

On the Dielectric Constants of Some Metal Vapors. (Ueber die Dielektrizitätskonstante einiger Metalldämpfe.) F. Krüger & F. Maske. *Physikalische Zeitschrift*, May 15, 1929, pages 314–320.

The dielectric constants of Hg and K vapor at 312 and 500° C., respectively, under a pressure up to 10 cm. and 1 cm. Hg, respectively, have been measured. The dielectric constants minus one proved to be proportional to the densities at these pressures. The equation of Maxwell $\epsilon = n^2$ was not fulfilled, but ϵ was in both cases larger than n^2. Extrapolation of the dielectric constants of the metallic vapors upon the liquid or solid state of aggregation by means of the formula given by Clausius-Mosotti was impossible since the values became negative. Reasons for this fact are indicated. EF

The Stainless Steels and Their Development. (Die rustfreien Stähle und ihre Entwicklung.) R. Schafer. *Giessereizeitung*, July 1, 1929, pages 361–371.

Some interesting data on the immense corrosion losses are given. Furthermore the development of the rustless steels, especially in England and Germany, is outlined. In numerous examples the advantageous application of these steels is discussed, for instance for pump pistons, steam valves, turbine blades and pipes. GN

The Position of the Maurer-Manganese Steel in the Development of Stainless Steels. (Der Maurer'sche Manganstahl in der Entwicklung der nichtrostenden Stähle.) E. Maurer. *Stahl und Eisen*, August 22, 1929, pages 1217–1220.

The author considers priority in the invention of stainless steels. He states that his investigations in 1912 on the heat treatment of chromium-nickel steels were undertaken to develop a rustless steel. The mentioned manganese steel (C:1.94%, Mn:2. 20%) is of importance insofar as in 1908 the investigator was the first successful in obtaining a homogeneous austenitic structure on quenching this steel from 1050° C. in ice water. GN

Contact Potentials between Pieces of the Same Metals. (Kontaktpotentiale zwischen gleichen Metallen.) W. Ende. *Physikallische Zeitschrift*, August 1, 1929, pages 477–489.

Differences of contact potentials between pieces of the same material the surfaces of which had been treated by different methods were determined in air and vacuum (uncooled and cooled by liquid air) with the object of decreasing the differences in contact potentials by the selection of proper surface treatment. The materials employed were brass, Ni and Pt. EF

Note on the Recovery of Platinum. G. J. Hough. *Industrial & Engineering Chemistry*, Analytical Edition, July 15, 1929, page 162.

A method is described for the recovery of platinum (also of alcohol) from the filtrates and residues obtained in the determination of potassium by the platinic chloride method. MEH

The Solubility of Gold in Mercury. Arthur A. Sunier & Bruce E. Gramkee. *Journal American Chemical Society*, June 1929, pages 1703–1708.

The evaporation method of analysis was used. The solubility of gold in mercury was determined between 80.8 and 201.1° C. and varied from 0.467 to 2.875 atomic percent. An empirical equation which expresses the solubility up to 160° C. is given. MEH

Reduction of Alkali-Tungstates with Hydrogen. (Die Reduktion von Alkaliwolframaten mit Wasserstoff.) J. A. M. Van Liempt. *Zeitschrift für anorganische und allgemeine Chemie*, July 20, 1929, pages 425–426.

Na_2Wo_4 is reduced by H_2 at higher temperatures according to the formula $Na_2WO_4 + 3H_2W + 2NaOH + 2H_2O$. At 1100° C. the reduction is quantitative. K_2WO_4 is not reduced by H_2. HA

Specific Resistance of Copper-Sulphide and Its Temperature Coefficient. (Der Spezifische Widerstand des Kupfersulfids und sein Temperaturkoeffizient.) Kurt Fiechbeck & Oskar Dorner. *Zeitschrift für anorganische und allgemeine Chemie*, July 20, 1929, pages 372–378.

Pure copper-sulphide is an excellent conductor of electricity; the resistance is about 21 times greater than that of copper. From the tests which are described in detail the specific resistance was found to be about 40 microhms/cm. The temperature coefficient was determined as 0.0037. HA

On the Orientation of Molecules on Solid Limiting Surfaces and the Limits of the Orienting Forces. (Ueber die Orientierung der Molekule an fester Grenzflache und über die Reichweite der Orientierenden Krafte.) D. Talmud. *Zeitschrift für physikalische Chemie*, July 1929, Abt. A, pages 233–236.

The author describes a new phenomenon which bears on the flotation process in preparing metal ores. If a mineral in powder form is mixed with water and a liquid insoluble in water is added which floats on the water the powder increases its volume. By addition of a very small amount of a mineral acid and shaking well all liquid retained by the powder is segregated and after a few hours the powder is precipitated to the bottom while the liquid collects on the surface of the water. HA

Carrying Out Investigations in the Range of High Temperatures. (Ueber die Durchführung von Untersuchungen im Gebiete hoher Temperaturen.) Willi M. Cohn. *Metallwirtschaft*, April 19, 1929, page 367–371; June 21, 1929, pages 599–602; June 28, 1929, pages 623–630.

Chemistry of high temperatures and importance of attaining high temperatures in science and industry are discussed. Preliminary conditions for carrying out investigations at high temperatures as velocity of heating, covered range and measurement of temperatures, gas phase, devices of observation, etc., are given. Materials of great stability at high temperatures; ceramic products (mainly based on Al_2O_3, SiO_2, MgO, CaO, C), elements (W, C, Ta, Os, Mo, Zr, Pt, V, Fe, Ni, etc.) and refractory oxides, carbides and nitrides are discussed and their principal properties, which are of interest for this special purpose, are given in tables. Materials refractory at 3000° C. are available. The principle of heating must be changed: the space must be insolated from the furnace walls by air, vacuum, etc. Operation at high temperatures is suitably subdivided into several stages: (1) up to 1500° C.; (2) temperatures between 1500 and 3000° C.; (3) temperatures above 3000° C. The classification of furnaces takes place according to the manner of heating into those using fuels and those which convert electricity into heat. In the present work the leading view points for the construction of both types of furnaces belonging to the different temperature stages are outlined and several typical representative furnaces illustrated. Stress has been laid upon the range of temperatures from 1500–3000° C. in which case either gaseous, solid and liquid fuel or electrical energy is applied. As representatives of the latter group, resistance furnaces, as carbon, iridium, tungsten and molybdenum furnaces, induction and high frequency furnaces are discussed. Operating at temperatures above 3000° C. is accomplished in arc furnaces (with direct, combined and indirect heating) and recently in cathode ray furnaces. Finally some possibilities of producing extremely high temperatures are suggested. The paper contains 9 tables, 22 illustrations and 36 references. EF

Systems of Borates and Halogen-Salts of Sodium in Fusion. (Ueber Systeme aus Boraten und Halogensalzen des Natriums in Schmelzfluss.) Bertil Ståhlhaüe. *Zeitschrift für Elektrochemie und angewandte physikalische Chemie*, August 1929, pages 486–492.

Equilibrium curves of the various halogen-salt systems have been determined, solubility and equilibrium conditions investigated. Methods of tests and results illustrate the paper. HA

What the Steelmaker Should Teach the Designer about Pipes and Cracks. (Was hat der Stahlgiesser dem Konstrukteur über Lunker und Rissbildung zu sagen.) A. Henvers. *Stahl und Eisen*, August 29, 1929, pages 1239–1256.

Paper before the annual convention of the "Verein deutscher Stahlformgiessersein" April 26, 1929. Includes discussion. The means for avoiding pipes and cracks in the production of steel castings are discussed. Poorly shaped designs of castings should not be cast. Designers should be better informed on steel foundry practice. GN

Tungsten Carbide Tools. *Journal Society Automotive Engineers*, September 1929, pages 307–308.

Descriptive bibliography of trade-paper articles and data from S. A. E. meetings. GN

Colloidal Platinum. V. The Coagulation by Electrolytes in Acid Solution. S. W. Pennycuick. *Journal of Chemical Society*, April 1929, pages 618–623.

The coagulation of platinum sol by addition of a neutral salt is shown to be caused by a cationic surface interchange, the cation of salt replacing the hydrogen ion of the surface hexahydroxyl acid. In acid solutions the cationic exchange is only partial and the coagulum contains some of the original surface acid. This is shown to explain the increase in the coagulation power of a salt as the pH of the sol is decreased. The coagulation process in general is discussed.

Colloidal Platinum. VI. The Behavior of Platinum Sols in Basic Solution. S. W. Pennycuick. *Journal of Chemical Society*, April 1929, pages 623–633.

From results obtained by the addition of bases to colloidal platinum solutions, it is concluded that approximately 25% of the colloid surface consists of hexahydroxyplatinic acid, the rest of the surface probably containing weakly acidic oxides of platinum. Such a constitution is shown to explain the many important reactions of colloidal platinum in basic solutions. Contrary to general belief, platinum sols are reversible.

On the Theory of the Plasticity of Metals. Hikorku Shoji. *Science Reports, Tohoku Imperial University*, May 1929, pages 1–9.

The formula for the measurement of plasticity, given by the investigator in a previous publication, is improved by this new theoretical investigation. GN

Translation

Negotiations are now under way which will assure the appearance of translations of articles appearing in foreign publications. Under this arrangement, the readers of METALS & ALLOYS *will be assured of receiving in English the best articles at almost the same time as they appear abroad instead of three months to one year later.*

Recrystallization of Electrolytic Copper after Hot Rolling

By W. Tafel*

In 1925, H. Hanemann and F. Lucke[1] published an investigation in which the authors give recrystallization curves of soft iron, steel with 0.49% C and electrolytic copper. The curves represent the result of investigations with upset cylindrical test pieces which were heated to a certain temperature before working and held at the same temperature for a certain period of time after working to produce recrystallization. At that time the opinion was expressed that the recrystallization curves take a different course after hot rolling since grain size after recrystallization possibly depends on the state of stress in the interior of the material. Recrystallization after hot rolling probably differs from that after forging. In order to throw light upon this question investigations were carried out in the subsequent years in the Rolling-Mill Experiment Station of the Technische Hochschule, Breslau. The object of this work was to study the different recrystallization behavior of soft iron after hot rolling in comparison with forging. The results of these investigations were given in a paper published early in 1929.[2]

The recrystallization curves obtained from hot-rolled soft iron do not check those found by Hanemann and Lucke. At first the curve of grain size after working below the peak-value and at temperatures above 900° C. are frequently not horizontal but fall off more or less sharply. Furthermore, the peak-value is shifted to the right at each temperature, i. e., the critical grain size therefore occurs only after greater deformation. The maximum limit of grain size exhibits lower values with rolling than with forging. In addition to this the slope of the curve beyond the peak-value differs materially from a hyperbola, i. e., the grain size is larger at higher pressures and does not—or only very slowly—sink below the grain size met before the peak-value.

The two investigations mentioned above refer exclusively to soft iron. The present work covers the same investigations for electrolytic copper.

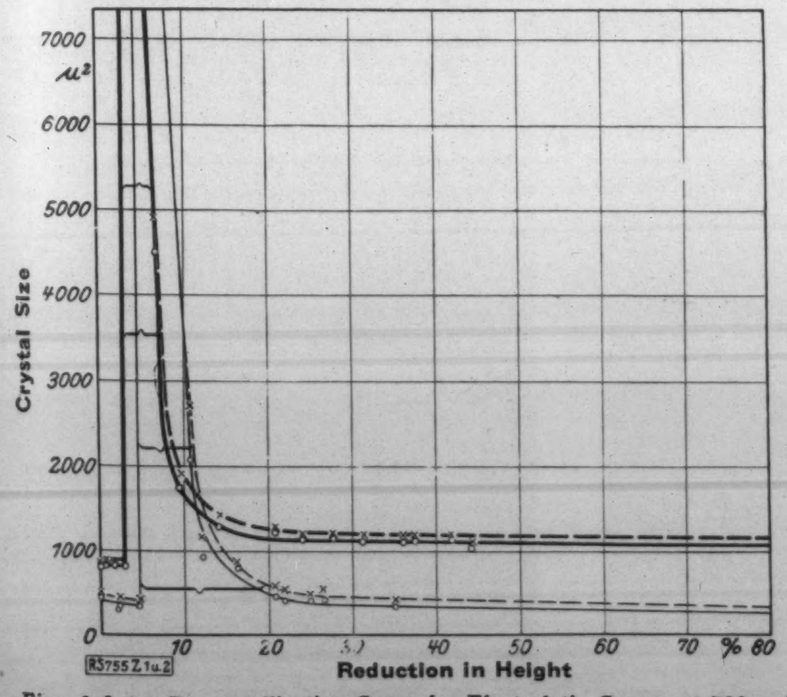
Recrystallization of Electrolytic Copper

In recent years much information was published on the recrystallization of copper.[3] In the present investigation the determination of the recrystallization curves took place in the same manner as previously in the case of soft iron, i. e., by interruption of the rolling process, so-called "transitions" were secured. The latter exhibit all degrees of deformation from zero to $\frac{h_1 - h_2}{h_1} \times 100$ in the same piece so that only one sample was required for each temperature. For checking and controlling purposes of some points on the curves several test pieces were rolled through. A difference between completely rolled pieces and the transition pieces could not be recognized as was also the case with soft iron.

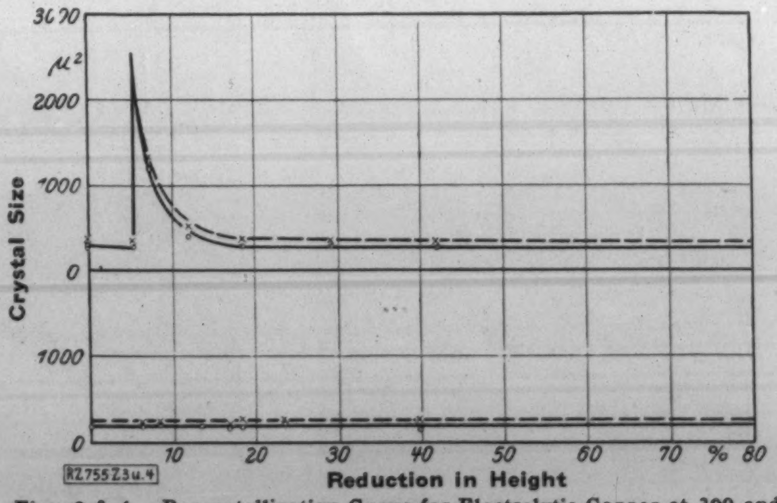
The different grain sizes corresponding to the various degrees of deformation (reduction in % of the initial height) were determined by counting out the grains by the method of Zay Jeffries. The slope of the curves results from Table 1. and are given in Figs. 1–5. Figs. 1–4 show the recrystallization curves corresponding to a certain temperature, whereas Fig. 5 represents the whole three dimensional recrystallization diagrams.

Deformation could only be checked up to 40% since above that value the rolls no longer grip. For larger deformations grain sizes are determined by interpolation.

In the cross-section of the transition pieces the boundary between fine-grained material before the peak-value and the coarse grain immediately after the latter does not yield a parabola as in case of soft iron, but takes a straight-line course perpendicular to the direction of rolling. See Fig. 6.[4] The determi-



Figs. 1 & 2.—Recrystallization Curve for Electrolytic Copper at 700 and 900° and Reductions in Height from 0 to 80%. Heavy Line at 900° C; Light Line at 700° C; Broken Line the Hanemann Curves



Figs. 3 & 4.—Recrystallization Curve for Electrolytic Copper at 300 and 500° and Reductions in Height from 0 to 80% Upper Line 500° C., Lower Line 300° C., Broken Line the Hanemann Curves nation of the grain size directly after the peak-value at temperatures of 700 and 900° C. was impossible since in this range of deformation and at this temperature no distinctly developed grains occur but chaotically arranged lamellar twins whose relation to one another could not be determined with certainty. (Figs. 8 and 9). However, the grain-size was far above 7000 μ^2, that is, above the coordinates of all the diagrams.

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* Rolling-Mill Experimental Station of the Technische Hochschule, Breslau. (Translated by a special arrangement from *Zeitschrift für Metallkunde*, August 1929, pages 265–267.)

[1] *Stahl und Eisen*, **45**, 1113–1122 (1925). Doctor thesis of F. Lucke, Technische Hochscule, Berlin-Charlottenburg, 1925.

[2] W. Tafel, H. Hanemann and A. Schneider, "Die Rekristallisation beim Warmwalzen," *Stahl und Eisen*, **49**, 7–12 (1929). Doctor thesis of A. Schneider, Technische Hochschule, Breslau, 1929.

[3] Among others F. Rassow and L. Velde, "Das Rekristallisations-diagramm des Kupfers," *Zeitschrift für Metallkunde*, **12**, 369–371 (1920). Dr.-Ing. Kühnel, "Einiges über Warmwalzen," *Zeitschrift für Metallkunde*, **16**, 99–103 and 138–141 (1924). H. Hanemann, "Darstellung des Rekristallisationsverlaufs auf Grund der Korngrössenänderung bei Warmverformung," *Zeitschrift für Metallkunde*, **17**, 316 (1925). E. Seidl and E. Schiebold, "Das Verhalten von Industriekupfer bei der Beanspruchung, erhärtet bei Kaltbehandlung," *Zeitschrift für Metallkunde*, **18**, 241–246, 315–321 and 343–346 (1926). W. Köster, "Die Beobachtungen an Kupfer zum gesetzmässigen Gefügeaufbau nach der Rekristallisation," *Zeitschrift für Metallkunde*, **18**, 112–116 (1926). W. Köster, "Einige Beobachtungen an Elektrolytkupfer," *Zeitschrift für Metallkunde*, **20**, 190 (1928).

[4] Since the microphotograph of the etched specimen did not sufficiently exhibit the peak-value of copper in comparison with soft iron due to greater light reflection the peak-value is schematically represented in Fig. 6. The distance ab′c corresponds to the curve obtained from soft iron and abc represents the straight-lined course of the peak-value of copper.

In regard to etching, difficulty first arose to find a suitable reagent allowing the clear recognition of the single crystals which partly exhibited twinned positions. Etching with 10% aqueous ammonium persulphate and treatment thereafter with an ammonical copper-ammonium chloride solution as proposed by E. Seidl and E. Schiebold did not yield such pictures with clearly distinguishable grain that reliable counting out could be performed. Therefore, another method of etching, which proved suitable in the preliminary tests, was chosen. The polished specimen was first treated with cotton containing a mixture of equal parts of ammonia and 3% hydrogen peroxide solution followed by slight polishing on the wheel which is only moistened with water. This operation was repeated several times. The last time the specimen was treated with the cotton swab until it took on a dark blue color due to the formation of ammonical copper oxide and until the surface of the sample turned slightly brown. The resulting microstructure contained clear grain boundaries in addition to a distinct surface coloration of the crystals orientated differently optically which facilitated considerably the determination of twin lamellae. In other words a combined etching of grain boundaries and crystal surfaces was attained. Figs. 7, 8 and 9 illustrate the microstructure obtained by this method of etching.[5]

Another question was whether twin crystals should be considered in the counting or not. Remembering that growth twins (formed during original crystallization) as well as deformation twins (those formed by turning down due to working parts of the crystal) exert an influence upon the physical properties of materials, both types of twins are considered as individual crystals. Only after a later request H. Hanemann communicated that in his curves, twins were taken into consideration as a single crystal. In order to compare the results from hot-rolling with Hanemann's results, the counting out of grains was repeated according to Hanemann. The new data (given as a broken line in Figs. 1–4), differ only slightly from those obtained previously. Grain sizes are located higher in the diagrams due to the number being increased by twin lamellae. Basically the slope of the curve remained unchanged.

As can obviously be seen from the figures, the recrystallization curves of copper after hot-rolling reveal similar deviations in comparison with Hanemann's curves after forging as was the case with soft iron. Grain size before the peak-value as well as in the region of critical deformation is larger. The curve indicates in some cases (at the working temperature of 500 and 700° C.) in their course before the peak-value a slope similar to that found in the case of soft iron. The

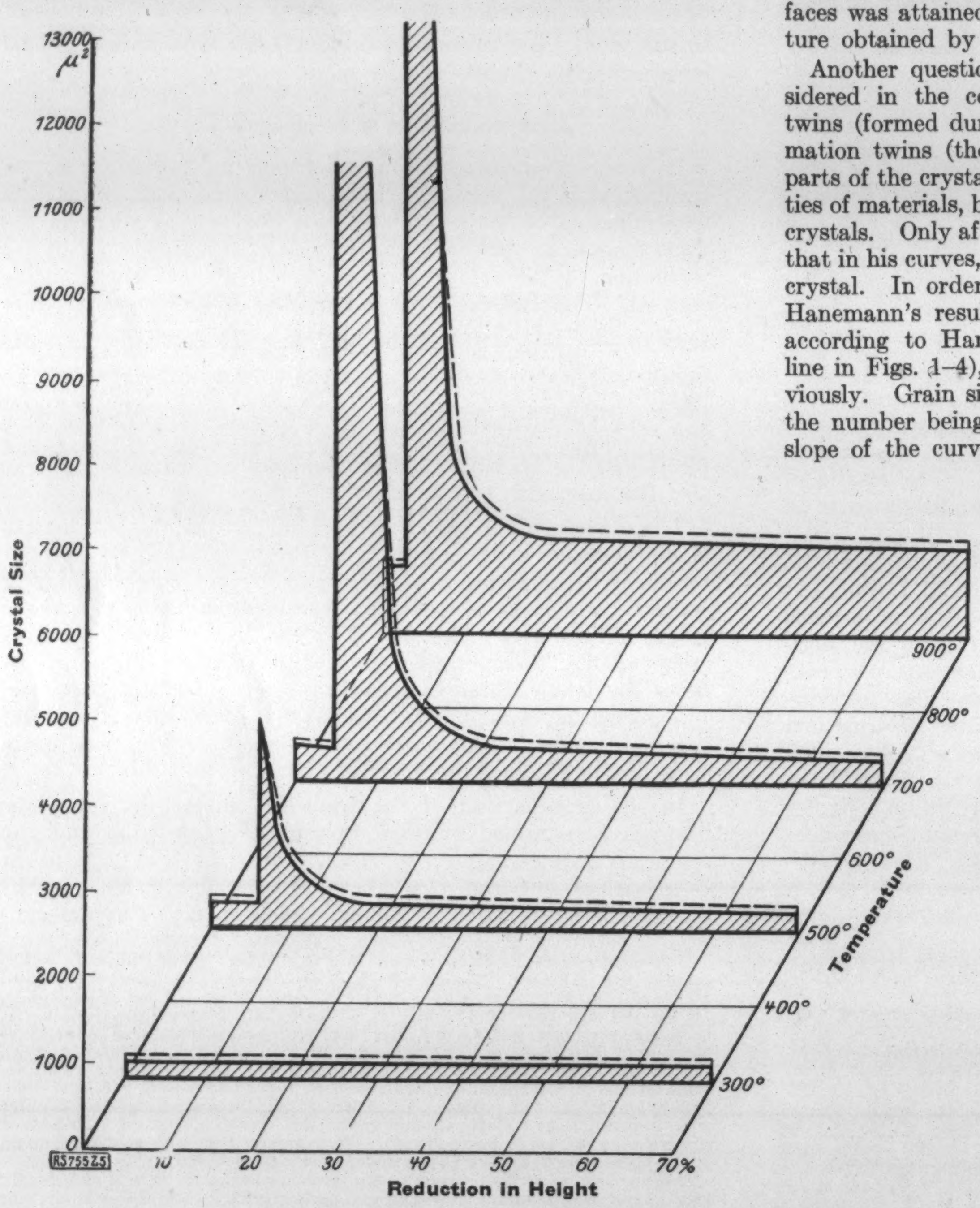

Fig. 5.—Three-Dimensional Diagram of Electrolytic Copper after Hot Rolling

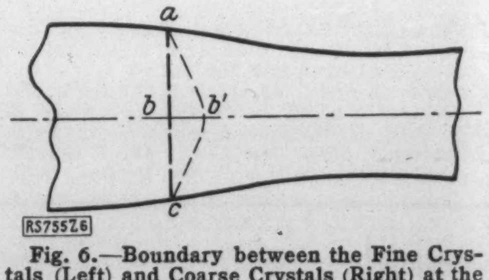

Fig. 6.—Boundary between the Fine Crystals (Left) and Coarse Crystals (Right) at the Peak Value. *abc* **for Copper,** *ab'c* **for Ingot Iron.**

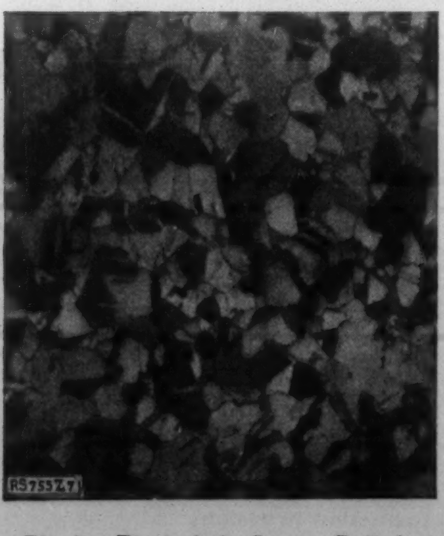

Fig. 7.—Electrolytic Copper Rolled at 900° C. Magnification 80 × (in Original 120 ×).

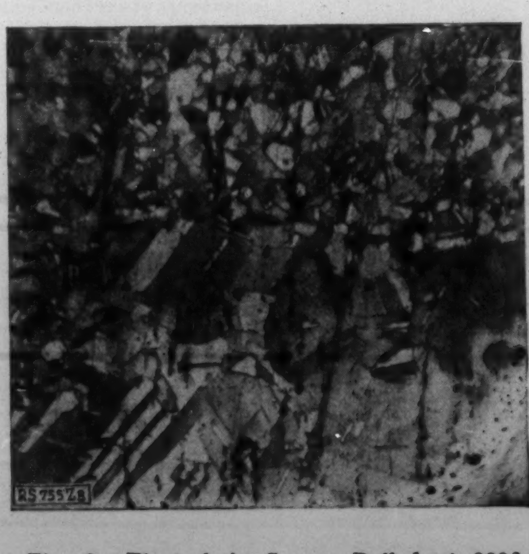

Fig. 8.—Electrolytic Copper Rolled at 900°; Transition (a) from Fine Grain to Coarse Grain in the Peak Value. 50× (77×)

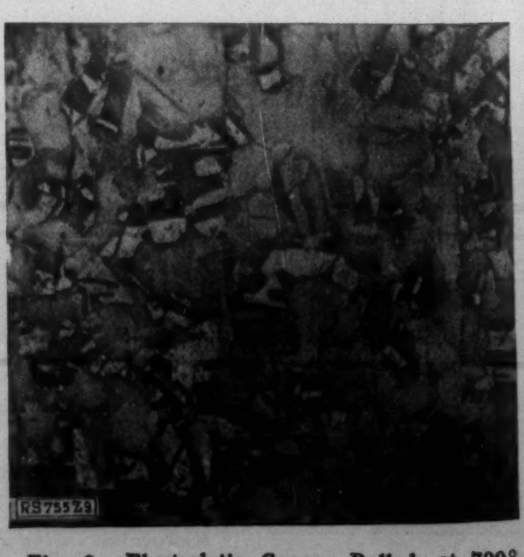

Fig. 9.—Electrolytic Copper Rolled at 700°. Photomicrograph Taken Near the Peak Value. 65 × (97 ×)

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[5] Taking Zay Jeffries' correction into consideration different magnification must be selected in order to obtain as closely as possible approximately equal number of grains into the areas destined for counting out.

peak-value is shifted to the right. In its further course, the curve differs from a hyperbola. The decrease of grain size makes slower progress with progressive deformation than encountered in forging down.

An attempt was made to find an explanation for the differences between Hanemann's and the present curves based on the principal difference of rolling and forging process. No satisfactory explanation can be given for the slope of the curve before the peak-value. The shifting to the right and the elevation of the curve is partly due to the fact that on gripping the bars the upper layers of the material–due to the friction of the rolls—are partly drawn into the latter, that is to say, the rolled material is tapered. The reduction in height is in part due to the rolling and in part due to the displacement of the particles along the rotating surfaces of the rolls. If the bar as a whole is rolled down to h_2 the calculation of the roll pressure thereby only considers a reduction in height to the larger value h_2. (See Fig. 10.) Thus the compression steps given along the abscissae are larger than those corresponding to the actual compression. The modified curve would, therefore, be shifted to the left and hence approach those of Hanemann.

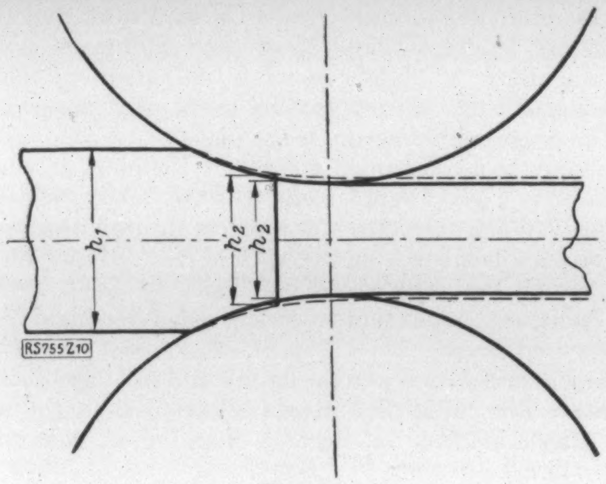

Fig. 10

Probably additional influences play a role in these discrepancies. One of those influences is based on the fact that during rolling the successive layers are stressed differently, i. e., the surfaces which are in contact with the rolls are displaced more in the direction of rolling than the inner layers. Attention may be called to the well-known experiment of Hollenberg. Due to this displacement internal stresses are caused which exert an influence on grain size. Indications that internal stresses influence the structure, have been given earlier by W. Tafel and O. Schmidt inasmuch as in Fig. 13 b of their investigation on heat stresses etc.,[6] Martensite and Osmondite could be shown in sharp steps along the separate surfaces of exactly fitting hardened materials which were pushed into each other.

Table 1—Crystal Sizes of Electrolytic Copper with Various Degrees of Deformation and Temperatures

Recrystallization Temperature

900°		700°		500°		300°	
Reduction in Height %	Crystal Size μ^2	Reduction in Height %	Crystal Size μ^2	Reduction in Height %	Crystal Size μ^2	Reduction in Height %	Crystal Size μ^2
0	782	0	443	0	311.7	0	185
0.667	802.5	0	429.7	0	297.5	0	180
1.667	798	2.23	360.7	5.57	266.3	6.5	195
2.777	peak-value	2.23	355.7	6.0	peak-value	8.33	205
6.667	4469	4.4	318	7.5	1190	13.32	190
9.45	1720	4.43	peak-value	12.23	382	16.72	168
14.167	1275.5	11.1	2486	18.67	287	18.34	170
20.833	1190.3	12.23	925.4	29.17	280	23.3	219
24.167	1105.5	16.36	780	42.0	261	39.8	179
27.777	1125	20.83	458.5				
31.43	1083	22.23	415.8				
36.25	1082.4	25.0	410				
37.62	1090.5	26.67	414.7				
44.443	997.3	42.01	352				

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[6] W. Tafel and O. Schmidt, "Wärmespannungen und ihr Einfluss auf Form- und Volumänderung beim Härten," *Der Betrieb*, **1**, 393–398 (1922).

Sam Tour has moved his headquarters from Batavia to 47 Fulton Street, New York, to take complete charge of the rapidly increasing amount of metallurgical consulting work of Lucius Pitkin, Inc.

No Standard "Government Bronze"

Certain metallurgical fallacies are so widespread among laymen that the Bureau of Standards finds it necessary to prepare mimeographed letter circulars to save labor in replying to inquiries about them. Among these fallacies, dealt with in previous letter circulars, are the idea that the government offers a prize for a method of "hardening copper,"[1] and the belief that metals "crystallize" under repeated stress.[2]

The Bureau has just issued another letter circular[3] dealing with the nomenclature of brass and bronze, in which occasion is taken to call attention to the fact that there is no one standard "government bronze."

Any of the letter circulars will be sent on request to the Bureau of Standards, Washington, D. C.

The paragraphs dealing with "government bronze" follow:

There is a widespread but erroneous belief that there is a definite composition of bronze officially accepted by the United States Government as the "best" bronze. One of the alloys of longest commercial use is that of 88% copper, 10% tin, 2% zinc or "88-10-2." Back in the days when cannon were made of bronze this was known as "gun bronze" and for many years the U. S. Navy had a specification for Navy "G" metal of this composition. American Society for Testing Materials specification B-10-18 covered this alloy, but is now replaced by B-60-28 for the 88-8-4 alloy.

The separate Navy specifications for this alloy are now superseded by the Federal Specifications Board specifications, and the 88-10-2 alloy does not appear therein (though it could, of course, be purchased by the government as a non-standard alloy if there were need for it). It is being superseded by Federal Specifications Board No. 5, 88-8-4 in which the tin content is lower and the zinc content higher, this composition being on the whole a better all-round alloy for a certain group of purposes than the 88-10-2.

But the 88-8-4 is no more a "government bronze" than any of the others in the Federal Specifications Board specification.

In the field of statuary bronzes or "art bronzes," there is a similar erroneous idea that there is one "government bronze," the composition of this one being set at 90% copper, 7% tin, 3% zinc. The history of this seems to be that back in 1895, in regard to the Hancock statue, it was specified in a letter by an individual purchasing officer that the "U. S. Standard bronze to be used should consist of 90 parts of copper, 7 parts of tin, 3 parts of New Jersey refined spelter." One or two firms, assuming that this phraseology had legal effect, set up this composition as, in their estimation, "U. S. Standard" and have claimed that the phrase should be used in somewhat the same manner as the terms "Sterling silver" or "Eighteen carat gold" are used. That, even in its statuary purchases, the government has not necessarily adhered to this "Standard" is shown by the fact that the bronze group in front of the Library of Congress was made of an alloy of 90% copper, 8% tin, 2% lead.

There is a prevalent idea that a statuary bronze must contain at least 90% copper, so that it will not stain a stone foundation, and that a similar copper content is required to allow the statue to acquire a pleasing patina. The correctness of these ideas seems doubtful. Various alloys exposed for over ten years at the Bureau of Standards show very little difference in color. One containing 80% copper, 3% tin, 16% zinc and 1% lead would apparently be a very satisfactory alloy for the purpose, as would one of 83% copper, 5% tin, 2% zinc and 10% lead.

Vickers (Metals and Their Alloys, 1923, pages 353–358) gives a wide range of compositions for art bronzes. Noted statues vary so in composition that it is clear that there are no fixed "ideal proportions" for art bronze, as well as no "U. S. Government Standard."

[1] Letter circular No. 61, Hardened copper.
[2] Letter circular No. 204, Metals do not "crystallize" under vibration.
[3] Letter circular No. 268, Nomenclature of the alloys "brass," "bronze" and so-called "government bronze."

Herman A. Holz, American representative of Amsler and Alpha testing machines, has moved his offices from 17 Madison Avenue to 167 East 33rd Street, New York, where he is occupying the penthouse on the roof of the building.

Book Reviews

Review of Hydrogen Ions—Their Determination and Importance in Pure and Industrial Chemistry. By DR. HUBERT T. S. BRITTON. Chapman & Hall, Ltd., London, 1929. Cloth $5^{1}/_{4} \times 8^{1}/_{2}$ inches, 515 pages, 108 figs. Price, 25 s.

This is the third volume of the series of monographs on Applied Chemistry under the editorship of Dr. E. Howard Tripp. It reviews various theories of electrometric methods for the determination of hydrogen ion concentration, assuming the correctness of conductivity data as leading to the true concentration of hydrogen ions, but does not treat of G. N. Lewis' "Activity" theory.

The preparation, uses and limitations of the various cells and electrodes and the measurement of e. m. f. are all given in splendid detail. The treatment of colorimetric methods for pH determination, with detailed discussion of apparatus and errors involved, is very good.

The chapter on errors in indicator methods, the use of indicators and the preparation of indicators, while very fine in their treatment of the subject matter covered, fall short in that some of the newer indicators have not been discussed. The analytical and industrial applications of hydrogen ion concentration are particularly well treated.

The importance of hydrogen ion concentration in the electrodeposition of metals, leather manufacture, sugar, pulp and paper, brewing, milk, baking, water purification, control of soils, ceramics, textile and dye industries, and ore flotation is emphasized. It is unfortunate that in a book of this nature, each of these subjects cannot be given greater space. This book serves to whet one's appetite to look further into each of these subjects, the bibliographies serving as a fine basis.

The chapter on miscellaneous industries treats of the manufacture of sweets, canning of food products, manufacture of fruit jellies, photography, emulsions, soaps, dentrifices, oil water emulsions in petroleum products and fire extinguishing foams. These are merely mentioned as indicative of additional applications of hydrogen ion control.

To the American reader the book might seem somewhat of a disappointment in that the chromium-plating industry, and biology from the clinical diagnostic and physiological viewpoints, are hardly mentioned, but in spite of these shortcomings, the book is a welcome collection of data not easily obtainable.—ARTHUR SCHRODER.

Recherches metrologiques sur les aciers au nickel. CH. ED. GUILLOME, Director, Bureau international des Poids et Mesures. Published by the Bureau, 1928. Cloth, $12^{1}/_{2} \times 9^{1}/_{2}$ inches. 242 pages. Price, 102 Francs.

A man may be investigating difficult problems, sometimes tedious, not seldom involving years of time, but the majority of us look for their solution, expect to terminate the work either with some direct results or by setting some definite limits to the undertaking. It takes an exceptional man to spend a lifetime in a study of a subject knowing that it will not be completed and will not bring any radical changes in the conception of the subject though furnishing material of utmost value to the later workers.

Being in charge of the Bureau international des Poids et Mesures, Mr. Guillome came in contact with the materials suitable for the manufacture of the primary standards and, wishing to check the constancy of the properties of metals started in 1891 the study of changes produced by time in measurable properties of a low expansion group of iron nickel alloys including invar. The present book presents the results of the work conducted continuously for more than a quarter of a century.

For a man in the shop the book hardly will be of an immediate value, but for those connected with the use or manufacture of accurate instruments or measuring devices this work opens a broad field of information backed by the high standing of its author. The reader is introduced to the methods giving results in the range of accuracy required for this type of work, properties affected by the time are discussed and a large amount of data fills the long existing gap in this field.—JOHN D. GAT.

Die Dauerfestigkeit der Werkstoffe und der Konstruktionselemente. By O. GRAF. J. Springer, Berlin, 1929. 131 pages, 166 figures, no index. Price, unbound, 14 R. M.; bound, 15.50 R. M.

This is a concise résumé of existing knowledge on endurance. It is not a mere handbook for the designer, and does not contain tables telling what endurance limit should be expected from a given alloy and heat-treatment. Instead, it points out the wide scatter of results on materials ostensibly similar, and discusses the factors affecting endurance. The treatment of the effect of notches and poor surface finish is quite complete. Strengthening by understressing is inadequately dealt with in half a page.

Most of the material is very much condensed. If one can read German easily, the book will be a useful summary, especially as it includes references to much recent German work, but the average American reader will find Moore and Kommers' or Gough's books on Fatigue of Metals easier to use, more complete, and better adapted to give a mental picture of what happens within a metal as progressive fracture takes place.

The preface to a companion volume by Föppl, et al. states that Graf's book is a good supplement to those books, which about sums it up. When one notes how much of the important information in the book is taken from the work of H. F. Moore, he realizes what a fine job Professor Moore has done.

Brief comment is included on stone, concrete, wood and glass under repeated stress.

The paper is very good and the figures and photographs delightfully clear. The table of contents allows finding the different subjects after a fashion, but the lack of an index is a handicap.—H. W. GILLETT.

Die Dauerprüfung der Werkstoffe. By O. FÖPPL, E. BECKER and G. VON HEYDEKAMPF. J. Springer, Berlin, 1929. 124 pages, 103 figures, no index. Price, unbound, 9.50 R. M.; bound, 10.75 R. M.

A companion treatise to that of Graf (see preceding review), equally well printed, and equally handicapped by lack of an index.

Methods of endurance testing are reviewed. Special emphasis is laid on the factors producing scatter of results, and on the effect of surface finish. Save for the presence of nuclei for failure, a homogeneous material would break down all over like the "one-hoss shay." The prevalence of fracture of test bars at other points than that of ostensible maximum stress shows the presence of such nuclei. Compression or working of the surface (see another article by Föppl[1]) is said to have a beneficial effect. Much stress is laid on hysteresis and damping effects, the logarithmic decrement is discussed, and, because they lend themselves to study of the damping effects, torsion machines for endurance testing are favored.

The necessity for a discrimination between tough and brittle materials for resistance to repeated stress and the smaller resistance to notch propagation in the latter are emphasized throughout.

Lehr's "accelerated" test in which the energy taken by the driving motor of the endurance testing machine is plotted for various loads, giving a curve similar to the "rise of temperature" curve is discussed, and the difficulty is emphasized of deciding where to draw the tangent whose intersection with the axis is alleged to show the endurance limit. The authors say that the question is still in dispute whether Lehr's method has any practical value. The Bohcuzewiez and Späth method of applying a static load, superimposing a dynamic load, and noting the beginning of plastic deformation appears to have somewhat more approval from the authors, but they state that whether the figure obtained from such a set of curves really coincides with the endurance limit requires further investigation.

The book is a real addition to the literature of fatigue testing.—H. W. GILLETT.

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[1] "Das Drücken der Oberfläche von Bauteilen aus Stahl," *Stahl und Eisen*, **49**, 575 (1929).

The Earth and Its Rhythms. By Chas. Schuchert & Clara M. LeVene. D. Appleton & Co., 1927. 410 pages, 175 figs. Price, $4.00.

Scientific knowledge is spreading, the authors say, into the ken of the man in the street, but geology has not received the attention it deserves in the campaign for popular understanding. This book aims to present to the layman, the story of rocks and the life record within them. It is popular geology and paleontology.

With the aid of 175 photographs and diagrams and a clear interesting style, the dose is made very palatable. There is nothing in it that will directly aid the metallurgist in his daily work. But as a relaxation, analogous to a detective story, it serves very well. It can be skimmed over without any attempt to remember the contents, with about the same interest with which one reads the National Geographic magazine. It would serve as an introduction to serious study, and its perusal will certainly excite further interest in the subject. It fulfills the object of its authors, and is a desirable addition to the list of books which tend to give the layman interest in and understanding of science. Moreover, it does it in a dignified and not a jazzy fashion.—H. W. Gillett.

Brass Founders' Alloys—A Practical Handbook. By John F. Buchanan. 2nd Edition 1928. E. & F. N. Spon, Ltd., London, Spon and Chamberlain, N. Y. 233 pages. Price, 11 s.

The preface states that the first edition was published when secrecy prevailed. The author broke away from tradition, and classified the useful alloys, tabulating only those alloys that have been proved sound in practice. The time is now ripe to include new alloys recently devised by coordination of effort in the laboratories and foundries.

With this preface one would expect considerable discrimination in the choice of the alloys listed. Yet one finds such alloys listed as "carbon bronze," 75% Cu, 10% Sn, 14.5% Pb, "carbon trace," with no statement as to the missing half-percent, how the carbon is added or what effect the carbon has, if any. It is stated that if 5% of a hardener made up of 75% iron, 25% zirconium is added to Al, an alloy of 3000 lbs./in.^{2} tensile strength results. As this is about a third of the tensile strength of the purest unalloyed aluminum, it is either a case of poor proof reading or a poor alloy.

References to sources of the information are not given so any such case cannot be chased down. An alloy of 55% germanium, 45% aluminum is said to be a corrosion-resistant aluminum solder melting at 423° C. That any aluminum solder is corrosion-resistant always requires proof, and the original reference would seem to be required. The alloy of 100 parts tin, 12 antimony, 8 copper, 8 vanadium is said to have density, tensile and compressive strengths increased by the vanadium. The Cu and V are melted together and poured into the molten Sn-Sb. Now it may be true that V will improve babbitt, but since few people have ever seen pure metallic V, much less used it, it would seem rather sweeping to assume that this alloy has as yet "proved sound in practice," without giving a reference to work justifying its inclusion in the list.

There is some interesting information. The 92% Al, 8% Cu alloy is said to be the most popular light foundry alloy. Most English foundry authorities have hitherto given the impression that one of about 15% Zn with say 2% Cu, rest Al, was the most common English alloy. That the 8% Cu is "invariably" purchased ready made in ingot form seems surprising, if true.

In discussion of babbitt, Buchanan states that he has had several "high class" alloys analyzed with the following results:

Cu	Sn	Sb	Zn	Pb
3.45	78.56	3.16	...	14.36
3.8	78.56	11.8	...	6.0
3.61	74.22	6.55	1.80	13.50
1.80	64.70	...	32.35	1.00

There are many well-recognized useful alloys listed, but there is little to tell the reader whether a given alloy is useful, or a freak or taken from some paper patent. The lack of references to other literature hampers the reader in seeking other sources of information.

The book is not without value, but is unsatisfying to the scientist and bewildering to the practical foundryman who might want to choose from the book an alloy fitted to a given purpose. He will find too many listed, and not critically discussed.—H. W. Gillett.

Tin, Its Mining, Production, Technology and Applications. By C. L. Mantell. A. C. S. Monograph No. 51, The Chemical Catalog Company, Inc., New York, 1929. 366 pages, 91 figs. Price, $7.00.

This is the story of a much used metal but one whose comprehensive treatment in the literature is almost as rare as its occurrence in nature. Dr. Mantell's comprehensive work should be invaluable to anyone concerned with tin and particularly to the chemist and metallurgist. His compilation of its chemical and physical data will save much searching over a broad field of published information. The purely descriptive portion covers in pleasing style the detailed history, occurrence and production of the metal, together with its commercial possibilities.

The author has drawn on his experience in presenting the interesting but difficult problem of gaseous reduction and the volume is dedicated to Dr. Fink, the author's co-worker on this problem. Well established methods of mining, ore dressing, smelting and refining are also described, including electrolytic processes, all of which might be difficult if not impossible to find so compactly elsewhere.

The important chemical facts about tin are included in different chapters of the book among various applications. One might prefer more physical metallurgy but much information of this character may be found in the chapter on alloys and elsewhere with the help of the subject index. Tin-containing alloys are discussed in much detail, even those carrying tin as a minor constituent. Secondary tin, its recovery as such and in the form of compounds is also given its proper place.

The information on tin plate, the most important use of tin, is meager but generally authentic. Industrialists should find much of interest in the presentation of the other industrial applications of tin and its general economies. Every popular corrosion is discussed from the standpoint of tin's interesting properties in this respect. The analytical chemist will find methods but, as the author suggests, space is not available for details.

In all, the book is well done. Errors and obscurities are few and the true meaning is usually at hand as on page 243 where "annealing" appears for pickling.—J. C. Whetzel.

Pipe and Tube Bending and Jointing. By Stanley P. Marks. Isaac Pitman & Sons, New York, 1929. Cloth, 5 × $7^{1}/_{2}$ inches. 159 pages, 80 figs. Price, 6 s.

The book deals primarily with pipe and tube bending and jointing in all their branches. The simplicity of treatment enables the book to be of value to all engaged in the working of metal pipes and tubes. The book is very well written. Lead, copper, aluminum, zinc, tin, iron and steel are the kinds of piping and tubing covered.—M.Berg Rimbach.

The Principles of Metallurgy. By John L. Bray. Ginn and Company, Boston, 1929. Cloth 6 × 9 inches, 568 pages, 248 figs. Price, $5.80.

Metals and alloys occupy such an important place in engineering that a knowledge of metallurgy is essential for all engineers. The author recognizing this need, has attempted to cover the field of metallurgy from the mining of the ore to the sale of the refined metal, in a single volume. The book is prepared as a text and is comprehensive enough for a principal text for chemical, mining or metallurgical students, but the reviewer doubts whether engineers in other branches can afford sufficient time to study this test. Undoubtedly all engineers should know much about metals but their time can be more profitably spent in studying the properties as construction materials.

In most cases in the discussion of processes, only the American practice is considered. Likewise the references at the end of each chapter include only publications in English.

The chapter on copper ends with a detailed description of two plants, matter somewhat out of place in a book supposed to be devoted to "principles." The least adequate seems to be the space devoted to alloy steels especially when we consider that we are now living in an "alloy" age. In the manufacture of wrought iron only hand puddling is considered, no mention being made of the recent Aston process. This book also contains many statements that the author will hardly be able to defend successfully. Its value would undoubtedly be materially increased if the subject matter of the various chapters were scrutinized by experts in the various fields.—Richard Rimbach.

Die Korrosion unter Berücksichtigung des Materialschutzes. By O. Kronke, E. Maass and D. W. Beck. Vol. 1—General and Theoretical (Vol. 10 of *Chemie und Technik der Gegenwart.* Edited by W. Roth). S Hirzel, Leipzig, 1929. 136 pages text, 61 pages bibliography, 10 pages index, 43 figs. Price, unbound, 16 R. M., cloth, 17.50 R. M.

This treatise on the theory and mechanism of corrosion deals with the subject from the standpoint of physical chemistry. The leading theories are described, but the authors lean heavily toward electrochemical explanations plus some straight chemistry. In general, the point of view coincides pretty well with those of U. R. Evans and of Speller, whose publications are constantly referred to through the book.

Fundamental theory is dealt with in the first part of this volume. (A second volume is promised to deal with corrosion of technically important metals and alloys.) Over-voltage and passivity are discussed. Considerable attention is paid to corrosion by gases and vapors, and by stray currents. Caustic embrittlement and intercrystalline corrosion are dealt with. Several illustrations are shown of intercrystalline attack on so-called pure aluminum, described only as 98–99% and of aluminum alloys, no composition being given. The type of attack shown is characteristic of alloys of the duralumin type, and not of ordinarily pure aluminum.

The second part of the book deals with protective coatings. There is not much hope, in the authors' minds, of getting impervious paint or varnish type coatings, or of getting electroplated coatings free from pores. True protection is only to be obtained by alloying so that the metal forms and maintains its own protective coating. Tammann's "rule of eighths" is referred to as a classic and taken much more seriously than most metallurgists will think it deserves.

The comment is made that nitride coatings, however important they may be from the point of view of surface hardening, have no practical significance from the point of view of protection against corrosion.

The book covers so much ground in such concise style that space is lacking to give even a list of the topics covered. It is not concerned with methods of corrosion testing, but sticks to theories of corrosion, and to a brief discussion of the fundamental facts about protective coatings without much detail.

It is well worth adding to the bookshelf of the metallurgist or chemist, and the second volume will be awaited with interest.—H. W. Gillett.

Lehrbuch der Metallhüttenkunde, Volume II. By Victor Tafel. XVI + 670 pages. S. Hirzel, Leipzig, 1929. Price, unbound, 55.50 R. M.; bound, 59 R. M.

This is the second and final volume of Tafel's text. Volume II deals with Bismuth, Lead, Tin, Antimony, Zinc, Mercury, Nickel and Aluminum. H. Wohlwill has written the sections on the electrolytic refining of bismuth, lead, tin and nickel. That portion of the chapter on zinc which discusses the production of technical zinc oxide has been written by F. Caspari, and those parts of the same chapter dealing with the production of electrolytic zinc are by O. Kühle. The entire chapter on aluminum is due to P. Prior.

It was the author's avowed intention as stated in the Preface to write a treatise on metallurgy, primarily for the student, describing the modern methods for the treatment of ores and their reduction to metals, showing how these methods are dependent on the physical and chemical properites of the metals, alloys and ore minerals in question in each case, and at the same time give to the student the commercial and engineering viewpoint of the various processes. The author has indeed succeeded to a high degree in the accomplishment of this aim.

The chapter on each metal starts with a brief historical sketch of the metal. The geographical distribution of the more important deposits of the metal are then shown on an outline map with graphical representation of the relative importance of the several localities. Production statistics are given in both tabular and graphical form. The important ore minerals of the metal are listed and their mineralogical characteristics concisely stated. Next the physical and chemical properties of the metal are considered and also such of its alloys as are of interest in connection with its recovery from ores and its purification. Constitutional diagrams are freely used. The properties of the chemical compounds of the metal are next in order and finally the methods for the production of the metal from its ores. This section of each chapter is replete with detailed and dimensional drawings of plant apparatus while at the same time the context does not hesitate to develop the theoretical side of the process.

The book is indeed a happy combination of theoretical and practical metallurgy, and while designed primarily as a text-book, will serve also as a convenient and up-to-date reference book.—Louis Jordan.

The Cooper Hewitt Electric Company will be known as the General Electric Vapor Lamp Company on and after January 1, it was announced to-day by William A. D. Evans, President. The trade-mark Cooper Hewitt heretofore used will be retained as the trade designation of the products manufactured by the General Electric Vapor Lamp Company, he stated.

"For the past ten years the Cooper Hewitt Company has been a subsidiary of the General Electric Company," Mr. Evans said, "And this change in name will coordinate its activities more closely with the General Electric Company itself and will also permit the wider use of the General Electric monogram. It is expected that from time to time the products of the company will be added to. There will be no change in the general policy or personnel of the organization."

The Cooper Hewitt Electric Company was formed in 1902 by George Westinghouse, Sr., and Dr. Peter Cooper Hewitt to exploit the pioneer inventions of the latter in mercury vapor apparatus.

The organization, whose plant is in Hoboken, New Jersey, specializes in the manufacture and sale of Cooper Hewitt lamps for industrial purposes, and for photographic studios, as well as quartz ultra-violet lamps, mercury switches, low voltage Neon tube lamps and Neon glow lamps.

L. N. Brown, formerly chief metallurgist of the Chrysler Motor Corp., Detroit, has been appointed general manager of the Cleveland plant of the Chicago Pneumatic Tool Co., Chicago. He succeeds P. J. Hamilton, who resigned to become sales manager of the Productive Equipment Co., Chicago.

The Case Hardening Service Co. has announced the appointment of **Mr. George C. Davis** of New York as its eastern distributor.

The Brown Instrument Company, Philadelphia, has appointed as its Chief Engineer, Mr. E. B. Nichols, well known for his previous connections, and his activities in the A. S. M. E.

Mr. Nichols, who is an M. E. graduate of North Carolina State College, was at one time Chief Engineer of the Pfaudler Company, Rochester, N. Y., subsequently holding the position of Chief Engineer of the Victor Talking Machine Company, Camden, N. J. Later he became associated with the Bell Telephone Laboratories, which connection he severed to join The Brown Instrument Company organization.

Mr. Nichols will act in an administrative capacity, supervising the work of the engineering staff. The past achievements of Mr. Nichols, his broad executive experience and ability in handling men and materials equip him particularly well for the varied and difficult problems presented in his new work.

J. R. Freeman, Jr., who has had long service with the Bureau of Standards as chief of the Section of Mechanical Metallurgy of the Metallurgical Division, went with the research laboratories of the American Brass Company the first of the year. Mr. Freeman is author of many metallurgical publications of the Bureau of Standards, some of his more recent work dealing in particular with rail steel.

E. B. Nichols has been appointed Chief Engineer of The Brown Instrument Company. Mr. Nichols is a graduate of North Carolina State College. At one time he was Chief Engineer of the Pfaudler Company, Rochester, N. Y., subsequently holding the position of Chief Engineer of the Victor Talking Machine Company, Camden, N. J. Later he became associated with the Bell Telephone Laboratories, which connection he severed to join The Brown Instrument Company.

Patent Department

Through an arrangement with Mr. W. M. Corse, Metallurgical Engineer, Washington, D. C., who operates a well-known Patent Information Service, we are able to publish every month a list of important patents in the metallurgical field from the United States, Canada and Europe. The following countries will be included in the European listing: England, Germany, France, Switzerland, Denmark, Norway, Sweden and Italy.

If our readers wish more information about any of the patents listed below they can get it by writing to our Patent Department, and mentioning the fact that they have seen the reference in METALS & ALLOYS. *We will be prepared to mail copies of United States Patents to clients within twenty-four hours of date of issue by special arrangement. Photostatic copies, translations of claims and of full text of foreign patents will be supplied if desired.*

This service is furnished under special arrangement with Mr. Corse's organization at most reasonable rates. Full information can be secured by writing to Patent Department, METALS & ALLOYS, *419 Fourth Avenue, New York.*

United States Patents

Patents issued from Nov. 19 to Dec. 10, 1929, inclusive.

Subject of Invention, Patentee, Patent No. and Filing Date.

Process for rustproofing articles of iron and steel. W. H. Allen, Detroit, Mich., assignor, by mesne assignments, to Parker Rust Proof Co., Detroit, Mich. No. 1,735,842. Aug. 11, 1928.

Wire-drawing apparatus. H. L. Blood, Oak Park, Ill., assignor to Western Electric Co., Inc., New York, N. Y. No. 1,735,846. June 8, 1927.

Wire-drawing apparatus. W. U. Boedeker, Chicago, Ill., assignor to Western Electric Co., Inc., New York, N. Y. No. 1,735,850. Sept. 3, 1926.

Nonoxidizing heating furnace. G. Keller, Brugg, Switzerland, assignor to Aktiengesellschaft Brown, Boveri & Cie, Baden, Switzerland. No. 1,735,866. May 13, 1926, in Germany May 30, 1925.

Wire-drawing apparatus. H. O. Olson, La Grange Park, Ill., assignor to Western Electric Company, Inc., New York, N. Y. No. 1,735,871. June 8, 1927, renewed July 10, 1929.

Device for measuring the current densities of galvanic baths. W. A. F. Pfanhauser, Leipzig, Germany. No. 1,735,878. May 7, 1928, in Germany Oct. 28, 1927.

Core-peeling device for foundries. R. Brune, Dortmund, Germany. No. 1,735,890. Oct. 23, 1926, in Germany Oct. 29, 1925.

Method of and apparatus for making articles of galvanoplastic metal. G. Rosenqvist, Pittsburgh, Pa. No. 1,735,909. Apr. 13, 1927.

Process in the manufacture of electrodes. M. O. Sem, Buffalo, N. Y. and C. W. Söderberg, Oslo, Norway, assignors to Det Norske Aktieselskab for Elektrokemisk Industri of Norway, Oslo, Norway. No. 1,735,936. Aug. 31, 1927, in Norway Sept. 4, 1926.

Roller hearth furnace. R. M. Hortvet, Minneapolis, Minn., assignor to Mahr Manufacturing Co., Minneapolis, Minn. No. 1,735,968. Sept. 28, 1928.

Centrifugal machine for casting metal pipes and the like. J. E. Hurst, Thorncliffe, England and E. B. Ball, Kilmarnock, Scotland assignors to Centrifugal Castings Ltd., Kilmarnock, Scotland. No. 1,735,969. Dec. 3, 1928, in Great Britain Jan. 4, 1928.

Open-hearth-furnace construction. A. L. Stevens, Evanston, Ill., assignor to A. L. Stevens Corp., Chicago, Ill. No. 1,736,023. Original May 16, 1927, divided and this application Sept. 14, 1928.

Nickel-chromium-iron alloy and articles made therefrom. W. Rohn, Hanau-on-the-Main, Germany. No. 1,736,053. Sept. 16, 1927, in Germany Nov. 23, 1925.

Apparatus for treating and blending moulders' sand. G. F. Royer, Wilkes-Barre, Pa., assignor to Royer Foundry and Machine Co., Wilkes-Barre, Pa. No. 1,736,055. July 12, 1927.

Method of using amalgams. L. H. Duschak, San Francisco, Calif., assignor, by mesne assignments, to Oliver United Filters, Inc., San Francisco, Calif. No. 1,736,072. June 22, 1925.

Apparatus for circulating and distributing flotation pulp. W. Fagergren, Salt Lake City, Utah, assignor to Universal Engineering Co., Salt Lake City, Utah. No. 1,736,073. Nov. 9, 1927.

Rolling and controlling the temperature of hot metal stock. J. R. George, Worcester, Mass., assignor to Morgan Construction Co. Worcester, Mass. No. 1,736,076. Aug. 3, 1925.

Tube-forming mill. R. C. Stiefel, Ellwood City, Pa. No. 1,736,099. July 14, 1928.

Separation of minerals and other substances. T. M. Davidson, Hatch End, Middlesex, England. No. 1,736,111. Sept. 14, 1926, in Great Britain Sept. 21, 1925.

Method and means for selectively controlling metal-pickling baths. J. H. Gravell, Elkins Park, Pa., assignor to American Chemical Paint Co. Ambler, Pa. No. 1,736,118. July 16, 1927.

Molybdenum alloy of iron and steel. A. Kissock, Forest Hills, N. Y. No. 1,736,120. Nov. 15, 1927.

Apparatus for pouring molten metal. J. R. Dressen, Peru and L. E. Wemple, Chicago, Ill., assignors to Illinois Zinc Co., Chicago, Ill. No. 1,736,188. June 27, 1928.

Bar-heating furnace. F. W. Brooke, Pittsburgh, Pa. No. 1,736,248. Dec. 31, 1927.

Process of treating metal to remove scale. C. Fischer, Jr., Wyoming, and L. A. Stegemeyer, Cincinnati, Ohio, assignors to the Twitchell Process Co., Cincinnati, Ohio. No. 1,736,282. May 25, 1928.

Continuous-casting machine. J. N. Davis, Denver, Colo., assignor to Battery Service Stations, Inc., Denver, Colo. No. 1,736,308. Jan. 21, 1928.

Process of forging axles. F. H. Moyer, Canton, Ohio, assignor to Central Alloy Steel Corp., New York, N. Y. No. 1,736,321. Apr. 28, 1926.

Strip-sheet manufacture. H. M. Naugle and A. J. Townsend, Canton, Ohio, assignors, by mesne assignments, to The American Rolling Mill Co., Middletown, Ohio. No. 1,736,324. May 24, 1927.

Channel-rolling mill. A. J. Townsend, Canton, Ohio, assignor, by mesne assignments, to The American Rolling Mill Company, Middletown, Ohio. No. 1,736,331. Aug.27, 1921.

Pickling process. J. C. Vignos, Canton, Ohio. No. 1,736,332. Aug. 29, 1928.

Molding-machine clamp. J. T. Ramsden, Philadelphia, Pa., assignor to The Tabor Manufacturing Co., Philadelphia, Pa. No. 1,736,363. Nov. 5, 1927.

Flask for multiple molding. J. T. Ramsden, Philadelphia, Pa., assignor to The Tabor Manufacturing Co., Philadelphia, Pa. No. 1,736,364. Mar. 15, 1928.

Strike-off mechanism for molding machines. J. T. Ramsden, Philadelphia, Pa., assignor to The Tabor Manufacturing Co. No. 1,736,365. May 22, 1928.

Shockless shake-out bail for molds. J. T. Ramsden, Philadelphia, Pa., assignor to The Tabor Manufacturing Co., Philadelphia, Pa. No. 1,736,366. May 22, 1928.

Oil-burning furnace. G. Niemkoff, Paris, France, assignor to Société Anonyme des Apparelis de Manutention et Fours Stein, Paris, France, No. 1,736,415. Aug. 19, 1921.

Centrifugal casting of hollow bodies of metal. J. C. Bell, Sheffield, England, assignor, by mesne assignments, to Centrifugal Pipe Corp., Wilmington, Del. No. 1,736,424. July 7, 1925, in Great Britain July 8, 1924.

Portable welding apparatus. H. E. Bryant, Providence, R. I., assignor, by mesne assignments, to Anaconda Wire and Cable Co. No. 1,736,428. Feb. 10, 1926, renewed May 4, 1929.

Composition of matter for and method of purifying fused salt baths. W. J. Merten, Pittsburgh, and C. T. Gayley, Swissvale, Pa., assignors to Westinghouse Electric and Manufacturing Co. No. 1,736,457. Oct. 10, 1925.

Deoxidizer (for obtaining inert atmospheres). C. J. Rodman and A. H. Maude, Wilkinsburg, Pa., assignor to Westinghouse Electric & Manufacturing Co. No. 1,736,464. July 20, 1923.

Molding machine. F. R. Wallace, Philadelphia, Pa., assignor to The Tabor Manufacturing Co., Philadelphia, Pa. No. 1,736,514. July 14, 1928.

Soaking-pit cover. L. Ellman, Pittsburgh, Pa., assignor to M. H. Detrick Co., Chicago, Ill. No. 1,736,524. Dec. 19, 1925.

Welded and calked body and process of producing same. M. Lachman, New York, N. Y., assignor to Bethlehem Steel Company. No. 1,736,539. Oct. 14, 1927.

Electric furnace. J. J. Frank, Pittsfield, Mass., assignor to General Electric Co. No. 1,736,587. Dec. 21, 1927.

Bearing for the rolls of rolling mills. L. Jones, Long Beach, N. Y. No. 1,736,601. May 14, 1927.

Method of beneficiating manganese ores. L. B. Miller, Cleveland, Ohio, and W. G. Rinehart, Batesville, Ark., assignors to said Miller. No. 1,736,615. Apr. 22, 1927.

Mechanically-operated butt welder. J. A. Muir, Detroit, Mich., assignor to Thompson Electric Welding Co., Lynn, Mass. No. 1,736,617. Nov. 11, 1926.

Hard solder particularly for grey pig iron, cast steel, iron and the like. E. Lay and C. Mattick, Frankfort-on-the-Main, Germany, assignors to American Lurgi Corp., New York, N. Y. No. 1,736,654. Feb. 15, 1928, in Germany Feb. 18, 1927.

Method of treating ores. T. A. Mitchell, Denver, Colo., assignor to Lafayette M. Hughes, Denver, Colo. No. 1,736,659. Oct. 11, 1926.

Method of chlorinating ores. T. A. Mitchell, Denver, Colo., assignor to Lafayette M. Hughes, Denver, Colo. No. 1,736,660. Oct. 11, 1926.

Process of extracting volatilizable metals from ores and metallurgical products. H. Pape, Oker/Harz, Germany, assignor to Fried, Krupp Grusonwerk Aktiengesellschaft, Magdeburg, Buckau, Germany. No. 1,736,665. Apr. 19, 1927, in Germany Apr. 26, 1926.

Method of and means for burning fuel in regenerative furnaces. M. C. Steese, Hamburg, N. Y. No. 1,736,675. Nov. 29, 1920.

Electrical heating body and method of manufacturing the same. H. Lohmann, Berlin-Wilmersdorf, Germany. No. 1,736,745. Mar. 15, 1928, in Germany Mar. 19, 1927.

Furnace rabble arm and tooth construction. G. E. Connolly, Oakland, Calif., assignor to Nichols Copper Co., New York, N. Y. No. 1,736,769. Mar. 5, 1927.

Electrodepositing apparatus. W. W. McCord, Wyandotte, Mich., assignor to McCord Radiator & Mfg. Co., Detroit, Mich. No. 1,736,857. July 6, 1926.

Method of making refractories. R. L. Frink, Lancaster, Ohio. No. 1,736,909. Sept. 18, 1926, renewed Oct. 24, 1928.

Surface-hardened material and method for producing the same. A. B. Kinzel, New York, N. Y., assignor to Electro Metallurgical Company. No. 1,736,919. July 28, 1927.

Case hardening. A. B. Kinzel, Bayside, N. Y., assignor to Electro Metallurgical Co. No. 1,736,920. Aug. 20, 1927.

Case nitrification of steel. A. B. Kinzel, Bayside, N. Y., assignor to Electro Metallurgical Co. No. 1,736,921. Feb. 13, 1928, renewed June 24, 1929.

Preparation of pickling baths. P. I. Murrill, Plainfield, N. J., assignor to R. T. Vanderbilt Co., Inc., New York, N. Y. No. 1,736,934. Nov. 22, 1928.

Galvanizing bath. N. K. Turnbull, Millport, Scotland. No. 1,736,948. June 13, 1928, in Great Britain June 14, 1927.

Apparatus for straightening metal bars and shapes. J. T. Leech, Beaver, Pa., assignor to Union Drawn Steel Co., Beaver Falls, Pa. No. 1,736,976. Mar. 31, 1925.

Protection of metallic surfaces against incrustation and corrosion. W. Thalhofer, Vienna, Austria, assignor to A.-G. für Chemische Industrie in Liechtenstein, Schaan, Liechtenstein. No. 1,736,986. Aug. 19, 1925, in Austria Aug. 21, 1924, renewed Oct. 15, 1929.

Protection of metallic surfaces against incrustations and deposits. W. Thalhofer, Vienna, Austria, assignor to A. G. für Chemische Industrie in Liechtenstein, Schaan, Liechtenstein. No. 1,736,987. Dec. 15, 1926, in Austria April 2, 1925.

Casting machine. N. H. Denner, Lakewood, Ohio. No. 1,737,001. Feb. 24, 1928.

Sintering apparatus. E. E. Ellis, Short Hills, N. J. No. 1,737,007. May 5, 1928.

Conveying roll for furnaces and the like. W. A. Morton, Pittsburgh, Pa., assignor to Amco, Inc., Pittsburgh, Pa. No. 1,737,117. Dec. 23, 1927.

Process for the recovery of tin and its associated metals from alloys, mechanical mixtures and ores. F. Bischitzky, Aussig-on-the-Elbe, Czechoslovakia. No. 1,737,140. May 25, 1926, in Germany July 5, 1924.

Sand-reconditioning machine for foundry art. L. A. Camerota, Burlington, N. J., assignor to W. Wood, Philadelphia, Pa. No. 1,737,144. June 5, 1928.

Hard alloy and process of manufacturing the same (W-Be-C). P. M. McKenna, Latrobe, Pa., assignor to Vanadium Alloys Steel Co., Latrobe, Pa. No. 1,737,255. Jan. 22, 1929.

Wire-drawing machine. C. E. Tideman, Worcester, Mass., assignor to Burlingame Machine Co., Worcester, Mass. No. 1,737,345. May 25, 1927.

Furnace, (open-hearth furnace). M. C. Steese, Hamburg, N. Y. No. 1,737,392. Dec. 13, 1920.

Electrochemical process for the extraction of copper and zinc from ores. H. S. MacKay, London, England. No. 1,737,425. Jan. 28, 1926, in Great Britain Sept. 24, 1925.

Electric furnace. P. Brown, Berlin, N. H., assignor to Brown Company, Berlin, N. H. No. 1,737,566. June 17, 1925.

Shrink-head casing for ingot molds. E. L. Messler, Pittsburgh, Pa., assignor to The Gathmann Engineering Co., Baltimore, Md. No. 1,737,665. July 6, 1925.

Hardening metal articles by nitrogenization. A. Fry, Essen, Germany, assignor, by mesne assignments, to the Nitralloy Corp. No. 1,737,711. Oct. 31, 1928, in Germany Nov. 17, 1927.

Concentration of ores. R. S. Handy, Kellogg, Idaho, assignor to Patino Mines & Enterprises Consolidated, Inc., New York, N. Y. No. 1,737,716. Sept. 13, 1928.

Process for flotation of cassiterite. R. S. Handy, Kellogg, Idaho, and R. R. Beard, Lallagua, Bolivia, assignors to Patino Mines & Enterprises Consolidated, Inc., New York, N. Y. No. 1,737,717. Nov. 13, 1928 in Bolivia Dec. 5, 1927.

Rolling mill. W. C. Coryell, Youngstown, Ohio, assignor to Central Alloy Steel Corp., Massillon, Ohio. No. 1,737,785. Apr. 5, 1923.

Method of and means for reducing stresses in welded pipe. J. R. Dawson, Flushing, N. Y., assignor to The Linde Air Products Co. No. 1,737,786. Nov. 27, 1925.

Treatment of ores. D. H. McIntosh, Salt Lake City, Utah, assignor of one-half to G. L. Oldright. No. 1,737,888. Dec. 24, 1926.

Apparatus and method of controlling electrodes in electric furnaces. F. X. Noichl and E. Schmidt, Burghausen, Oberbayern, Germany, assigners to Dr. A. W. Gesellschaft für Electrochemische Industrie, Munich, Bavaria, Germany. No. 1,737,890. Feb. 19, 1929, in Germany Apr. 27. 1927.

Method of expanding metal. H. M. Gersman, Buffalo, N. Y. No. 1,737,998. Oct. 9, 1926.

Recuperative annealing furnace. F. T. Cope, Salem, Ohio, assignor to The Electric Furnace Co., Salem, Ohio. No. 1,738,038. Aug. 20, 1926.

Continuous furnace. F. T. Cope and A. H. Vaughan, Salem, Ohio, assignors to The Electric Furnace Co., Salem, Ohio. No. 1,738,039. Mar. 29, 1928.

Sealing means for furnace cars. F. T. Cope, Salem, Ohio, assignor to The Electric Furnace Co., Salem, Ohio. No. 1,738,040. Nov. 2, 1928.

Quenching device for drill steels. C. C. Hansen, Easton, Pa., assignor to Ingersoll-Rand Co., Jersey City, N. J. No. 1,738,050. Jan. 28, 1928.

Apparatus and method for forming extensions upon tubes. A. T. Hunter, University City, Mo., assignor to International Combustion Engineering Corp., New York, N. Y. No. 1,738,056. Oct. 2, 1928.

Tube-rolling machine. H. H. Stephens, Topeka, Kans. No. 1,738,125. Nov. 10, 1927.

Continuous-heat annealing furnace. F. J. Winder, Brackenridge, Pa., assignor to Allegheny Steel Co. No. 1,738,130. Mar. 30, 1928.

Bearing. H. M. Williams, Dayton, Ohio, assignor to General Motors Research Corp., Detroit, Mich. No. 1,738,163. Apr. 11, 1927.

Hot-top-holding clip. A. R. Rowe, Midland, Pa. No. 1,738,209. Sept. 6, 1928.

Cutting electrode. R. W. Holt, Chicago, Ill., assignor to Fusion Welding Corp., Chicago, Ill. No. 1,738,246. Oct. 11, 1926.

Hot-blast cupola. C. D. Barr, Birmingham, Ala., assignor to American Cast Iron Pipe Co., Birmingham, Ala. No. 1,738,277. Nov. 15, 1927.

Metallic element (Method of growing large crystals). L. W. McKeehan, Maplewood, N. J., assignor to Bell Telephone Laboratories, Inc., New York, N. Y. No. 1,738,307. Apr. 11, 1927.

Conveyer table for cross-roll mills. L. A. Woodard, Zanesville, Ohio. No. 1,738,340. Feb. 23, 1928.

Electrolytic cell (for deposition of metals). R. Edgeworth-Johnstone, London, England. No. 1,738,372. Jan. 10, 1929, in Great Britain Nov. 4, 1927.

Core box. J. B. Lukomski, Detroit, Mich. No. 1,738,380. Nov. 5, 1928.

Pickling apparatus. S. L. Williams, Bridgeport, Ohio, assignor to Extruded Metal Products Co., Bridgeport, Ohio. No. 1,738,412. Mar. 22, 1929.

Process of making pressed-steel car wheels. J. R. Winter, Warren, Ohio, assignor to Youngstown Pressed Steel Company, Warren, Ohio. No. 1,738,414. Dec. 22, 1928.

Electric furnace. A. N. Otis and G. W. Hegel, Schenectady, N. Y., assignors to General Electric Co. No. 1,738,446. Oct. 24, 1928.

Resistance element. W. B. Smits, Kassel-Wilhelmshohe, Germany. No. 1,738,456. June 30, 1928, in Czechoslovakia Feb. 23, 1928.

Line welding. R. E. Wagner and W. E. Laird, Pittsfield, Mass., assignors to General Electric Company. No. 1,738,465. Jan. 19, 1922.

Method of making fasces bolt stock. T. S. Wheelwright, Richmond, Va., assignor to Old Dominion Iron and Steel Works, Richmond, Va. No. 1,738,487. Jan. 18, 1927.

Electroplating apparatus. W. E. Belke, Chicago, Ill. No. 1,738,515. Mar. 31, 1927.

Furnace arch. B. Dobie, Chicago, Ill., assignor to American Arch Co. No. 1,738,527. Aug. 18, 1924.

Arc welding. E. S. Goodspeed, assignor to General Motors Corp., both of Detroit, Mich. No. 1,738,573. July 22, 1920.

Blast-furnace operation. W. A. Haven, Youngstown, O. No. 1,738,577. Apr. 9, 1927.

Furnace arch. R. J. Himmelright, New York, N. Y., assignor to American Arch Co. No. 1,738,580. Aug. 15, 1924.

Welding apparatus. F. C. Leonard, Providence, R. I., assignor to Leonard-Rooke Co., Providence, R. I. No. 1,738,592. Dec. 8, 1925.

Process of and apparatus for producing pressed railway-car axles and similar forgings. F. Lützenkirchen, Hattingen-Ruhr, Germany. No. 1,738,593. Nov. 5, 1926.

Hot top. E. L. Messler and J. M. Guthrie, Pittsburgh, Pa.; said Guthrie assignor to J. Thomas, Sharpsville, Pa. No. 1,738,600. Oct. 31, 1928.

Method of enriching iron ore, blast furnace flue dust, burnt pyrite, purple ore and the like. H. A. Mueller, Stockholm, Sweden, assignor to Aktiebolaget Ferriconcentrat, Stockholm, Sweden. No. 1,738,603. Aug. 22, 1927.

Method of reducing rare refractory-metal oxides. M. N. Rich, East Orange, N. J., assignor to Westinghouse Lamp Co. No. 1,738,669. Nov. 9, 1927.

Furnace. W. H. Wineman, Chicago, Ill., assignor to Sullivan Machinery Co. No. 1,738,680. June 13, 1923.

Apparatus for use in the electrolytic deposition of metal on metal tubes. F. J. Pike, Beckenham, and C. J. Lyth, Woolwich, London, assignors to J. Stone & Co. Ltd., Deptford, England. No. 1,738,727. Jan. 30, 1929.

Corrosion-resisting coating. R. J. Wirshing and H. R. Faas, Detroit, Mich., assignors to General Motors Research Corp., Detroit, Mich. No. 1,738,748. Mar. 15, 1928.

Soldering apparatus. J. F. Schylander, Chicago, Ill. No. 1,738,800. May 13, 1927.

Low-resistance permanent wire. A. H. Jackson, Huntington Park, Calif. No. 1,738,828. Mar. 2, 1925.

Ingot mold. R. F. Furness, Jenkintown, Pa. No. 1,738,882. Feb. 21, 1928.

Blast-furnace tuyère. E. H. Holzworth, Buffalo, N. Y. No. 1,738,901. July 11, 1927.

Electric melting pot. F. Kuhn and L. H. Thomas, Detroit, Mich., assignors to American Electrical Heater Co., Detroit, Mich. No. 1,738,908. Feb. 13, 1928.

Production of zinc. R. Lepsoe, Trail, British Colombia. No. 1,738,910. June 24, 1927.

Process for preparing slimes derived from wet washing of gas for sintering. A. J. Boynton, Winnetka, Ill., assignor to H. A. Brassert & Co., Chicago, Ill. No. 1,738,940. Oct. 27, 1927.

Hotbed for rolling mills. R. R. Bolt, Buffalo, N. Y.; A. F. Bolt, administratrix of said R. R. Bolt, deceased. No. 1,738,983. Mar. 10, 1927.

Electric resistance welding of pipe. W. E. Crawford, Wauwatosa, and Reimar C. F. Kurtze, Milwaukee, Wis., assignors to A. O. Smith Corp., Milwaukee, Wis. No. 1,739,063. Mar. 12, 1928.

Method of producing materials in finely-divided form. J. E. Harris, Newark, N. J., assignor to Bell Telephone Laboratories, Inc., New York, N. Y. No. 1,739,068. Jan. 31, 1929.

Method of reclaiming car axles. J. R. Blakeslee, Willoughby, O., assignor to The Ajax Manufacturing Co., Euclid, O. No. 1,739,119. Dec. 10, 1926.

Method of making ductile high-silicon-steel sheets. R. R. Curry, Tarentum, Pa., assignor to Allegheny Steel Co., Brackenridge, Pa. No. 1,739,126. July 27, 1927.

Head for movable riveting machines. E. W. Larsen, Milwaukee, Wis., assignor to A. O. Smith Corp., Milwaukee, Wis. No. 1,739,152. May 17, 1920.

Four-high mill. O. B. Lindquist, Tarentum, Pa., assignor to Allegheny Steel Co., Brackenridge, Pa. No. 1,739,156. Apr. 6, 1927.

Shrink-head casing for ingot molds. E. Gathmann, Baltimore, Md. No. 1,739,222. July 14, 1928.

Process of making metal filaments. R. Jacoby and F. Koref, Berlin, Germany. assignors to General Electric Co. No. 1,739,234. June 1, 1922.

Method of reclaiming railway-car axles. W. B. Martin, Cleveland Heights, Ohio. No. 1,739,248. Sept. 14, 1928.

Machine for folding sheet metal. F. Menne, Weidenau-on-the-Sieg, Germany, assignor to H. F. Hoevel, New York, N. Y. No. 1,739,249. Mar. 17, 1928.

Furnace. F. Menne, Weidenau-on-the-Sieg, Germany, assignor to H. F. Hoevel, New York, N. Y. No. 1,739,250. June 7, 1928.

Method of making steel. T. F. Baily, Alliance, O. No. 1,739,278. Mar. 11, 1926.

Melting and refining furnace. T. F. Baily, Alliance, O. No. 1,739,343. Jan. 28, 1928.

Electric furnace. T. F. Baily, Alliance, O. No. 1,739,344. Jan. 28, 1928.

Method of and apparatus for coating metal articles. D. G. Griswold, Wallingford, Conn., assignor to R. Wallace & Sons Mfg. Co., Wallingford, Conn. No. 1,739,482. Dec. 29, 1922.

Austrian Patents

Subject of Invention, Patentee, and Patent No.

Patents whose term began June 15, 1929, except where noted.

Froth flotation apparatus. F. P. Egeberg, Oslo, Norway. No. 115,329.

Method of hot-rolling metals. Sundwiger Eisenhütte Maschinenbau Akt.-Ges., Sundwig, Kr. Iserlohn, Germany. No. 115,183.

Drive for rolling mill with supporting rolls. Aktiebolaget Svenska Kullagerfabriken, Göteborg, Sweden. No. 115,196.

Roller bed with two or more adjacent guide troughs for the rolled material. F. Krupp Grusonwerk Akt.-Ges., Magdeburg-Buckau, Germany. No. 115,202. (Addition to No. 105,573).

Machine for rolling seamless tubing. R. Urban, Podbrezová, Czechoslovakia. No. 115,436.

Process for the reduction to carbon monoxide of the carbon dioxide in the carbon dioxide-containing gases obtained in the reduction of ores. F. M. Wiberg. Falun, Sweden. No. 115,211.

Welded double-walled slag and blast tuyères for blast furnaces. Górnoslaskie Zjednoczone Huty Królewska I. Laura Spolka Akcyjna Górniczo-Hutnicza, Kattowitz, Poland. No. 115,217.

Charging device for shaft furnaces of all types. Akt.-Ges. Brown Boveri & Cie., Baden, Switzerland. No. 115,212.

Process for making highly porous lead aggregates. I. G. Farbenindustrie Akt-Ges., Frankfurt a.M., Germany. No. 115,371.

Process for making finely-porous metals. I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany. No. 115,390.

Pipe-molding ramming machine. R. Ardelt, Eberswalde i.d.Mark, Germany. No. 115,265.

Process for making electrolytic deposits of different thicknesses. P. Bruckmann & Söhne Akt.-Ges., Heilbronn, Germany. No. 115,213.

Variable-stroke press. F. H. Parkstone, Dorset, England. No. 115,177.

Press tool. F. H. Parkstone, Dorset, England. No. 115,171.

Means for supplying current to one or more welds at the same time from the same welding generator. Akt.-Ges. Brown Boveri & Cie., Baden, Switzerland. No. 115,206.

Soldering iron for continuous soldering and solder wire therefor. M. Orenstein, Berlin, Germany. No. 115,207.

Process and machine for making pipe. K. Breitenbach, Siegen i.W., Germany. No. 115,141. (Term began Apr. 15, 1929.)

Process for making refractory materials. J. I. Bronn, Berlin-Charlottenburg, Germany. No. 115,239.

British Patents

(Complete Specifications Accepted.)

Subject of Invention, Patentee, Patent No., and Filing Date.

Annealing and heat-treating furnaces. A. T. Kathner. No. 320,841. Apr. 16, 1928.

Magnetic alloys. Siemens & Halske Akt.-Ges. No. 290,658. May 20, 1927.

Cast iron alloys. Molybdenum Corp. of America. No. 289,075. April 21, 1927.

Treatment of ores or other matter containing acid-oxide forming metals, such chromium, manganese, molybdenum, titanium, uranium and the like, for the formation of salts thereof and useful by-products. R. W. Stimson. No. 320,845. April 21, 1928.

Hard metal compositions. British Thomson-Houston Co., Ltd. No. 289,477. Apr. 28, 1927.

Process for the manufacture of refractory materials having a base of bauxite, and the product resulting therefrom. Soc. Anon. Des Manufactures Des Glaces Et Produits Chimiques De St. Gobain, Chauny, Et Cirey. No. 294,179. July 19, 1927.

Process for producing a coating of chromium on objects of iron and steel or aluminum and particularly on knives, forks and spoons. Dr. H. Leiser. No. 294,484. July 21, 1927.

Extrusion of metal. British Insulated Cables, Ltd. and J. G. Lauder. No. 320,928. July 24, 1928.

Lined bearing and method of making same. W. Klocke. No. 320,943. July 27, 1928.

Moulds for casting metals. A. E. White (Aluminum, Ltd.). No. 320,947. July 27, 1928.

Methods of electrolytically depositing chromium. Soc. Chimique De La Seine and V. Szidon. No. 320,952. July 28, 1928.

Methods of and apparatus for storing alkali and other readily oxidizable metals. British Thomson-Houston Co., Ltd. No. 296,347. Aug. 29, 1927.

Hard metal alloy for tools. J. Bertram. No. 320,991. Aug. 23, 1928.

Method of introducing highly-active metals into sealed containers. Westinghouse Lamp Co. No. 296,781. Sept. 9, 1927.

Apparatus for cutting metal by the combustion of gases. T. R. Hancock, and R. S. Solomon. No. 321,004. Sept. 7, 1928.

Manufacture of tubes, rods or bars. Bromford Tube Co., Ltd., J. J. Reimann, and M. Reimann. No. 321,017. Sept. 21, 1928.

Wire-feeding mechanism for welding-machines. British Thomson-Houston Co., Ltd. No. 301,044. Nov. 23, 1927.

Device for greasing mechanically the trunnions of rolling-mill cylinders with lubricants kept under pressure. H. Firquet. No. 301,506. Dec. 1, 1927.

Liquid-metal casting-ladles. K. R. Binks. No. 321,106. Dec. 24, 1928.

Process for the production of metal-wound copper wires. Siemens & Halske Akt.-Ges. No. 307,080. March 3, 1928.

Manufacture of chromium articles. Electrical Research Products, Inc. No. 309,539. April 12, 1928.

Methods of electrolytically depositing chromium. Soc. Chimique De La Seine and V. Szidon. No. 320,959. July 28, 1928.

Annealing and heat-treating furnaces. A. T. Kathner. No. 320,865. April 16, 1928.

Metallic alloys. Barber Asphalt Co. No. 294,233. July 21, 1927.

Apparatus for centrifugal casting hollow metal bodies. A. K. Croad (Sand Spun Products Corp.). No. 321,158. July 27, 1928.

Recovery of copper from ores and the like. H. Lavers and B. Taplin. No. 321,213. Aug. 2, 1928.

Welding machines. Gas Accumulator Co. (United Kingdom) Ltd., (S. A. Eskilson). No. 321,273. Sept. 11, 1928.

Apparatus for use in electric arc welding. Quasi-Arc Co., Ltd. and R. J. Musto. No. 321,279. Sept. 20, 1928.

Manufacture and production of finely divided metals. J. Y. Johnson (I. G. Farbenindustrie Akt.-Ges.). No. 321,336. Nov. 19, 1928.

Steel Swages. P. F. M. Aubert, A. J. P. Duval and H. A. M. Duval, (trading as Aubert and Duval Freres). No. 305,539. Feb. 6, 1928.

Electric melting-furnace. Electric Furnace Co., Ltd. No. 305,952. Feb. 11, 1928.

Bearing-metals and methods of manufacturing the same. International General Electric Co., Inc. No. 308,983. Apr. 2, 1928.

Production of compact masses from pulverulent metallic oxides. J. Y. Johnson (I. G. Farbenindustrie Akt.-Ges.). No. 321,394. May. 29, 1928.

Coating of metals with metals. A. H. Marks and P. Russell (legal representatives of E. C. R. Marks (deceased)). (American Machine & Foundry Co). No. 321,407. June 29, 1928.

Coating of metal articles with rubber or similar material. Dunlop Rubber Co., Ltd., D. F. Twiss and E. A. Murphy. No. 321,398. July 6, 1928.

Process for the utilization of sulphur-bearing gases from ore roasting or sintering operations. National Processes, Ltd., and T. B. Gyles. No. 321,390. July 27, 1928.

Processes for coating metallic or non-metallic bodies with vanadium. S. G. S. Dicker (Naamlooze Vennootschap Philips' Gloeilampenfabrieken). No. 321,391. July 27, 1928.

Process for manufacturing, out of by-products, ferrous bricks for use as iron ore in various metal furnaces. Soc. Lorraine Des Aciéries De Rombas. No. 295,051. Aug. 6, 1927.

Apparatus for the manufacture of metal tubes and other tubular metal articles. Wellman Seaver Rolling Mill Co., Ltd., and S. Smith. No. 321,529. Oct. 19, 1928.

Manufacture of metal tubes. H. W. Bundy. No. 300,643. Nov. 18, 1927.

Close annealing-covers. J. Summers & Sons, Ltd., H. B. Freeman and De Bergue & Co., Ltd. No. 321,545. Nov. 7, 1928.

Method or process for jointing aluminium by solder. H. Jackson. No. 321,554. Nov. 10, 1928.

Induction heating-apparatus. O. Neiss and H. Bollmann. No. 301,868. Dec. 7, 1927.

Presses for drawing sheet metal. A. E. White (Hamilton Press and Machinery Co.). No. 321,579. Dec. 4, 1928.

Machines for cold bending metal tubes. C. Mingori. No. 321,600. Jan. 11, 1929.

Moulds for casting metals. Metallges. Akt.-Ges., V. M. Goldschmidt, and K. Stenvik. No. 321,609. Jan. 24, 1929.

Method and apparatus for casting molten metal under pressure. R. H. V. Christensen. No. 306,958. Feb. 29, 1928.

Canadian Patents

Subject of Invention, Patentee, Patent No., and Filing Date.

Process of concentrating oxidized ores and minerals. F. A. Bird, Salt Lake City, Utah. No. 294,389. June 27, 1927.

Method of treating ore concentrates. J. M. Tippett, Victor, Colo. No. 294,464. May 16, 1927.

Production of pure iron. H. J. van Royen, Hörde, Westfalen, Germany. No. 294,465. Nov. 24, 1927.

Annealing pot. The American Brake Shoe and Foundry Co., New York, N. Y., assignee of R. S. Stewart (deceased), Chicago, Ill. No. 294,474. Aug. 20, 1928.

Heating furnace. The American Sheet and Tin Plate Co., Pittsburgh, Pa., assignee of A. R. McArthur, Gary, Ind. and H. G. McIlvried, McCandless Township, Pa. No. 294,476. Apr. 10, 1928.

Production of metal rods or tubes. Robert Bosch Akt.-Ges., Stuttgart, assignee of F. Ehrmann, Stuttgart-Feuerbach, Germany. No. 294,482. Jan. 27, 1927.

Multiple-hearth furnace. Nichols Copper Co., New York, N. Y., assignee of E. M. Fowler, Redwood City, Calif., executrix of estate of E. J. Fowler (deceased), Redwood City, Calif., and D. Baird, Berkeley, Calif. No. 294,545. Oct. 22, 1928.

Apparatus and process for treating ores. F. M. Simonds and A. F. Hyde, assignee of one-half interest, both of New York, N. Y. No. 294,594. Mar. 12, 1927.

Molding sand. H. O. Berg, Paris, and G. Michel, Bagneux, France. No. 294,599. Sept. 17, 1925.

Electrode holder (for electric furnaces). E. Molmark, Ambridge, Pa. No. 294,601. Oct. 3, 1928.

Process and composition for rust-proofing iron, steel, etc. W. H. Cole, Paris, France. No. 294,633. Apr. 11, 1928.

Copper tempering process. J. A. Dionne, Cabano, Que. No. 294,636. Aug. 7, 1929.

Process for producing metals and alloys. T. R. Haglund, Stockholm, Sweden. No. 294,649. Feb. 1, 1928.

Concentrator. W. A. Huelsdonk, Fresno, Calif. No. 294,652. July 16, 1928.

Method of preparing refractory metals. The Canadian Westinghouse Co., Ltd., Hamilton, Ont., assignee of J. W. Marden, East Orange, N. J. and T. P. Thomas, East Pittsburgh, Pa., and J. E. Conley, Denver, Colo. No. 294,703. Mar. 13, 1924.

Refractory metal filament. The Canadian Westinghouse Co., Ltd., Hamilton, Ont., assignee of M. N. Rich, East Orange, N. J. No. 294,704. Oct. 15, 1926.

Method of annealing worked bodies. The Canadian Westinghouse Co., Ltd., Hamilton, Ont., assignee of W. B. Gero, Bloomfield, N. J., No. 294,705. Feb. 3, 1927.

Vibration and sag-resistant filament. The Canadian Westinghouse Co., Ltd., Hamilton, Ont., assignee of J. H. Ramage, Bloomfield, N. J. No. 294,706. Apr. 30, 1927.

Production of aluminum alloys having a high percentage of silicon. Th. Goldschmidt Akt.-Ges., assignee of A. Walter, both of Essen, Ruhr, Germany. No. 294,735. Aug. 3, 1926.

Process of improving aluminum alloys. Th. Goldschmidt Akt.-Ges., assignee of W. Sander, both of Essen-Ruhr, Germany. No. 294,736. Jan. 20, 1928.

Method of forming drawn articles. The Kelsey-Hayes Wheel Corp., assignee of J. E. Batie, both of Detroit, Mich. No. 294,760. Mar. 12, 1928.

Manufacture of mild steel plates, sections, etc. The Martinel Steel Co., Ltd. Liverpool, assignee of F. G. Martinel, Higher Bebington, Cheshire, England. No. 294,763. Feb. 16, 1925.

Method for improving the texture of hollow metal bodies. The United States Cast Iron Pipe and Foundry Co., Burlington, N. J., assignee of F. C. Langenberg, New York, N. Y. No. 294,815. June 6, 1929.

Apparatus for removing excess molten materials. H. B. Newhall, assignee of H. W. Pleister, both of Westfield, N. J. No. 294,827. June 29, 1929.

Method of roasting sulfide minerals. J. B. Read and M. F. Coolbaugh, both of Golden, Colo. No. 294,837. Sept. 24, 1928.

Metal working and products thereof. (Conditioning manganese steel.) The Taylor-Wharton Iron and Steel Co., High Bridge, N. J., assignee of G. R. Hanks, Clinton, N. J. No. 294,980. Nov. 19, 1927.

Manufacture and repair of centrifugal molds. The United States Cast Iron Pipe and Foundry Co., Burlington, N. J., assignee of F. C. Langenberg, New York, N. Y. No. 294,983. June 6, 1929.

Process and apparatus for forging crankshafts. The Wyman-Gordon Co., Worcester, Mass., assignee of A. J. Larcher, Chicago, Ill. No. 294,988. Jan. 7, 1929.

Cutting torch device. C. F. March, Toronto, Ont. No. 295,059. Mar. 14, 1929.

Apparatus for placer mills. J. H. Ratcliffe, San Diego, Calif. No. 295,066. Oct. 29, 1926.

Process for briquetting dust-like materials without binding materials. A. Uhlmann, Berlin-Steglitz, Germany. No. 295,080. Dec. 8, 1927.

Welding machine. The Edward G. Budd Manufacturing Co., assignee of J. J. Paugh, both of Philadelphia, Pa. No. 295,110. Jan. 2, 1929.

Process for making heavy duty springs. The Edgewater Steel Co., assignee of F. B. Bell and O. R. Wikander, all of Pittsburgh, Pa. No. 295,128. July 22, 1926.

Apparatus for the direct production of iron. The Gathmys Research Corp., assignee of S. L. Madorsky, both of Chicago, Ill. No. 295,141. Dec. 23, 1925.

Danish Patents

Subject of Invention, Patentee, Patent No., and Filing Date.

Process for making a lead-antimony alloy for the sheaths of electric cables and the like. Standard Electric A.S., Oslo, Norway. No. 40,841. Jan. 27, 1928.

Die casting machine. J. Polak, Prague, Czechoslovakia. No. 40,874. May 18, 1927.

Magnesium alloy for the pistons of internal combustion motors. I. G. Farbenindustrie Akt.-Ges., Frankfurt a. M., Germany. No. 40,937. June 27, 1928.

Device for winding up metal wire. N. Nielson, S. C. Sorensen, both of Boulstrup, Bjerager Sogn, Denmark. No. 40,954. Oct. 8, 1928.

French Patents

Subject of Invention, Patentee, Patent No., and Filing Date.

Process for the elimination of sulphur from the residues of roasted pyrites, from crude sulphides and other materials containing sulphur. Fried. Krupp Grusonwerk Akt.-Ges. No. 673,026. Apr. 12, 1929.

Improvements in the electrolytic recovery of metals. S. C. Smith. No. 673,035. Apr. 12, 1929.

Process for treating titanium ores containing chromium, with recovery of sulphuric acid. Deutsche Gasglühlicht Auer G. m. b. H. No. 673,076. Apr. 13, 1929.

Process for making objects of metallic alloys. I. G. Farbenindustrie Akt.-Ges. No. 673,094. Apr. 15, 1929.

Treatment of substances containing nickel. S. C. Smith. No. 673,119. Apr. 15, 1929.

Electric furnace installation for the heat treatment of tools and small objects. L. D. J. Tisseyre. Addition Patent No. 35,680. (First addition to No. 662,292.) May 24, 1928.

Improvements to the process for the regular reproduction of irregular surfaces. Metal Forming Process, Inc. No. 673,115. Apr. 15, 1929.

Arrangement of electric induction furnaces not having a closed ferromagnetic circuit. Allmänna Svenska Elektriska Aktiebolaget. No. 673,091. Apr. 15, 1929.

Apparatus for refining graphite by flotation. H. Grandin. No. 673,153. Aug. 9, 1927.

Washing apparatus for graphite. H. Grandin. No. 673,154. Aug. 9, 1927.

Improvements in the treatment of malleable cast iron. Compagnie Française pour l'Exploitation des Procédés Thomson-Houston. No. 673,222. Apr. 2, 1929.

Ferro-aluminum. Société Aubert et Duval Frères. No. 673,352. Aug. 1, 1928.

Process for the direct extraction of a metal, particularly iron, from its ores, and furnace installations for working this process. A. Langer. No. 673,456. Apr. 16, 1929.

Treatment of materials containing zinc, calcined zinc oxides, mixtures of zinc and lead oxides, roasted zinc ores, etc. Zaklady Hohenlohego-Hohenlohe-Werke Spolka Akcyjna. No. 673,534. Apr. 18, 1929.

Improvements to processes for coating ferrous metals with basic salts. A. Levy. No. 673,667. Aug. 14, 1928.

Process for coating male or female cylindrical mechanical elements with a hard wear-resistant material. E. H. Tartrais. No. 673,254. Apr. 11, 1929.

Improvements to foundry molding flasks. A. B. Smith and C. R. Smith. No. 673,256. Apr. 11, 1929.

Electric soldering iron. E. A. Varinot. No. 673,390. Aug. 4, 1928.

Soldering process and composition therefor. P. L. and M. Company. No. 673,443. Apr. 16, 1929.

Rolling mill for making balls. O. Hering. No. 673,606. Apr. 20, 1929.

Process for the simple and rapid manufacture of tin plate. Rasselsteiner Eisenwerks Ges. Akt-Ges., and H. Frambs. No. 673,621. Apr. 20, 1929.

Improvements to electric induction furnaces. Compagnie Française pour l'Exploitation des Procédés Thomson-Houston. No. 673,258. Apr. 12, 1929.

Improvements to machines for heating, upsetting and welding by resistance. J. E. Languepin. No 673,284. June 8, 1928.

Process for the production of partially localized electrolytic deposits, especially applicable to chromium plating. S. Dreyfus. No. 673,382. Aug. 3, 1928.

Low-density refractory material for filling and lining high-temperature furnaces. C. Chilowski. No. 673,371. Aug. 2, 1928.

Process for the dry cleaning of coal, ore, stone mixtures or other substances. Maschinenfabrik Fr. Groppel C. Luhrig's Nachfolger. No. 674,135. Apr. 25, 1929.

Molding machine. E. Leyondre. No. 673,731. Aug. 28, 1928.

Improvements to furnaces, especially those for annealing certain metals. Compagnie Française pour l'Exploitation des Procédés Thomson-Houston. No. 673,812. Apr. 19, 1929.

Process for making steel. G. A. Code. No. 673,960. Apr. 24, 1929.

Process for the preparation of metallic carbonyls. I. G. Farbenindustrie Akt.-Ges. No. 674,216. Apr. 29, 1929.

Joining of endless metal screens. Compagnie Générale d'Electricité. No. 673,748. Aug. 31, 1928.

New process for the internal welding of metallic objects. A. Bagnulo. No. 673,757. Sept. 3, 1928.

Improvements in the manufacture by extrusion of lead cable sheaths and the like. W. T. Henley's Telegraph Works Co., Ltd. No. 673,804. Apr. 18, 1929.

Improvements to apparatus for treating steel tubes or their equivalents in suitable baths. The Perfecta Seamless Tube and Conduit Co., Ltd., and H. Trevorrlw. No. 673,868. Apr. 22, 1929.

Improvements to presses for working sheet metal. C. J. Rhodes. No. 673,913. Apr. 24, 1929.

Process for making castings of an alloy of tungsten or molybdenum carbides with a metal or metalloid of lower melting point, or with a carbide of these substances. Fried. Krupp Akt.-Ges. No. 673,880. Apr. 23, 1929.

Process for covering the surface of metals with an alloy. Research Corporation. No. 673,971. Apr. 23, 1929.

Molding press for the production of double molds in a single flask. G. Eckstein. No. 674,088. Apr. 26, 1929.

Improvements to processes and to apparatus for soldering metallic wires. Compagnie des Lampes. No. 674,138. Apr. 23, 1929.

Hydraulic shock absorber for sheet-stamping presses and similar presses. Marquette Tool and Manufacturing Co. No. 674,151. Apr. 26, 1929.

Process for making self-baking electrodes. Det Norske Aktieselskab for Elektrokemisk Industri. No. 673,945. Apr. 24, 1929.

German Patents

Subject of Invention, Patentee, Patent No., and Filing Date.

Device for the separation of dust from dry fine-grained material. Maschinenfabrik Buckau R. Wolf Akt.-Ges., Madgeburg, Germany. No. 486,546. Aug. 30, 1927.

Air-settling table. H. M. Sutton, W. L. Steele and E. G. Steele, Dallas, Tex. No. 486,684. Feb. 13, 1926.

Process and machine for pressing or rolling hollow bodies into shapes. Fried Krupp Akt.-Ges., Essen. a.d. Ruhr, Germany. No. 486,690. Oct. 6, 1928.

Process for making constricted metal disks, for example of copper, by rolling. Osnabrücker Kupfer und Drahtwerk, Osnabrück, Germany. No. 486,691. Nov. 4, 1927.

Means for increasing the pressure of an air blast, especially the combustion air for blast-furnace hot stoves, Cowper stoves and the like. Askania-Werke Akt-Ges., vormals Centralwerkstatt Dessau- und Carl Bamberg-Friedenau, Berlin-Friedenau, Germany. No. 486,651. Feb. 1, 1929.

Process and apparatus for the reduction of molten ores in a reverberatory furnace. H. C. Hansen, Berlin, Germany. No. 486,499. Mar. 29, 1925.

Compound cylindrical conveyor element. A. T. Kathner, New Cumberland, Va. No. 486,500. June 28, 1928.

Means for changing the resistance of heating elements in the molten condition in refractory troughs. Studien-Gesellschaft für Wirtschaft und Industrie m.b.H., Munich, Germany. No. 486,555. (Addition to No. 457,074.) Nov. 22, 1925.

Method of and apparatus for charging melting furnaces. Badische Maschinenfabrik & Eisengiesserei vormals G. Sebold and Sebold & Neff, Durlach, Germany. No. 486,523. (Addition to No. 480,856.) Nov. 18, 1927.

Method of and means for maintaining the purity of protective layers of pulverulent thermally insulating materials placed on molten metals. Allgemeine Elektrizitäts Gesellschaft, Berlin, Germany. No. 486,524. Apr. 23, 1929, in the United States Apr. 21, 1928.

Jar molding machine for pipe molds. A. Possenti and C. Scorza, Pesaro, Italy. No. 486,444. June 29, 1928.

Process for degassing light metals, especially aluminum and aluminum alloys. Vereinigte Aluminium-Werke Akt.-Ges., Lautaerk, Lausitz, Germany. No. 496,525. June 13, 1928.

Inalterable white-metal alloy. C. Philippossian, Geneva, Switzerland. No. 486,451. Feb. 24, 1929, in Switzerland Nov. 3, 1928.

Process for the production of beryllium alloys by fusion electrolysis, especially those with high beryllium content. Siemens & Halske Akt.-Ges., Berlin-Siemensstadt, Germany. No. 486,452. Nov. 14, 1928.

Apparatus for annealing strips. C. Storck, Leipzig, Germany. No. 486,662. Dec. 23, 1927.

Device for baths for the treatment of objects, especially electrolytic baths. Siemens & Halske Akt.-Ges., Berlin-Siemensstadt, Germany. No. 486,531. (Addition to No. 485,744.) Feb. 19, 1928.

Process for preventing the splitting off of enamel. A. Nadolny, Berlin, Germany. No. 486,458. Apr. 1, 1928.

Process for beating metal foil. Metallpapier-Bronzefarben-Blattmetallwerke Akt.-Ges., Munich, Germany. No. 486,459. Jan. 27, 1928.

Welding and soldering burner. Hermann Schelske & Co., Berlin-Neukölln, Germany. No. 486,825. July 21, 1926.

Guide-around trough for roll trains. B. Quast, Rodenkirchen, near Köln, Germany. No. 487,010. Dec. 30, 1928.

Press for making seamless tubing, with displaceable guide elements for the mandrel. Press- und Walzwerk Akt.-Ges., Düsseldorf-Reisholz, Germany. No. 486,761. Aug. 23, 1928.

Process for making structural steels. E. Bosshardt, Berlin-Tempelhof, Germany. No. 486,956. (Addition to No. 398,208.) July 5, 1925.

Process for the surface improvement of metals and metallic objects. Deutsche Edelstahlwerke Akt.-Ges., Bochum, Germany. No. 486,834. May 8, 1923.

Electric heating element. H. Schmid, Cannstatt, Germany. No. 486,975. Sept. 22, 1927.

Device for producing high temperatures by means of electrically superheated flames. G. T. Southgate, Birmingham, Ala. No. 486,874. Mar. 8, 1923, in the United States Mar. 8, 1922.

Welding machine with one movable and one stationary electrode. Edward G. Budd Manufacturing Co., Philadelphia, Pa. No. 486,933. Nov. 24, 1926, in the United States Nov. 24, 1925.

Compressed-air control for molding presses. Alfelder Maschinen-u. Modellfabrik Künkel, Wagner & Co., Alfeld, Leine, Germany. No. 487,130. Sept. 7, 1928.

Device for removing deposits from rotary kilns. Fried. Krupp Grusonwerk Akt.-Ges., Magdeburg-Buckau, Germany. No. 486,982. Jan. 22, 1928.

Recovery of tin from alloys and mechanical mixtures. F. Bischitzky, Aussig, Czechoslovakia. No. 487,006. July 6, 1924.

Process for recovering metals by distillation. I. G. Farbenindustrie Akt.-Ges., Frankfurt a.M., Germany. No. 486,961. (Addition to No. 426,544.) Mar. 14, 1926.

Production of copper alloys. Metallgesellschaft Akt.-Ges., Frankfurt a.M., Germany. No. 486,937. July 28, 1926.

Magnetic-separation device. Fried. Krupp Grusonwerk Akt.-Ges., Magdeburg-Buckau, Germany. No. 487,167. Nov. 15, 1925.

Lifting table for rolling mills. A. Hesse, Lüdenscheid, Germany. No. 487,251. Jan. 9, 1929.

Machine for making wire nails. J. Wikschtröm, Düsseldorf, Germany. No. 487,327. Feb. 26, 1924.

Process for making large electrodes with metal inserts. Siemens Planiawerke Akt.-Ges. für Kohlefabrikate, Berlin-Lichtenberg, Germany. No. 487,426. May 3, 1925.

Switch system for a spot welding machine. Siemens-Schuckertwerke Akt.-Ges., Berlin-Siemensstadt, Germany. No. 487,193. Nov. 13, 1926.

Packing device for roasting or sintering machines having a movable grate and working under increased or reduced pressure. Compagnie des Metaux Overpelt-Lommel (Société Anonyme), Overpelt-lez-Neerpelt, Belgium. No. 487,206. Mar. 14, 1928, in Belgium July 20, 1927.

Process for producing platings of metallic beryllium on metals or alloys. Siemens & Halske Akt.-Ges., Berlin-Siemensstadt, Germany. No. 487,278. (Addition to No. 485,103.) Oct. 9, 1926.

Process for making bimetallic strips or plates for thermostats. F. W. Miller, Hockley Heath, Warwickshire, England. No. 487,144. Apr. 17, 1927, in Great Britain Apr. 21, 1926.

Process for making laminated metals, especially with a surface of precious metal G. Stock, Mittelhasslach, Germany. No. 487,410. Jan. 1, 1927.

Italian Patents

Subject of Invention, Patentee, Patent No., and Filing Date

Process for the production of pure aluminum in compact form from crude aluminum, aluminum alloys and the like. Aluminium Industrie Akt.-Ges., Neuhausen, Schaffhausen, Switzerland. No. 262,644. Sept. 9, 1927.

Process for the production of electrolytic deposits of various kinds. Berndorfer Metallwarenfabrik Arthur Kapp Akt.-Ges., Berndorf, Austria. No. 262,641. Sept. 16, 1927.

Process and apparatus for the mechanical purification of metals and non-metallic ingredients. Braunschweiger Hüttenwerk G.m.b.H., Melverode, Braunschweig, Germany. No. 262,513. June 22, 1927, in Germany July 2, 1926 (in the name of T. Piep).

Purification of iron ore and extraction of the various metals present in the form of sulphides. T. Cavalli, Padua, Italy. No. 262,624. Apr. 25, 1927.

Lead alloy for bearings. S. Cholewinski, Warsaw, Poland. No. 262,811. Oct. 5, 1927.

Improvements in the working of the process for the electrolytic recovery of tin from tinplate scrap. A. Dossmann, Genoa, Italy. No. 262,626. May 16, 1927.

Method for the preparation of briquettes of coal and the like and for their continuous delivery to metallurgical furnaces. New Jersey Zinc Co., New York, N. Y. No. 262,711. Mar. 11, 1927, in the United States Mar. 25, 1926 (in the names of F. G. Breyer and E. H. Bunce).

Improvements to alloys of nickel, cobalt and iron. W. S. Smith, Benchams, Devonshire; J. H. Garnett, Lymne, Sevenoaks, Kent; and J. A. Holden, Sunnyside, Essex, England. No. 262,825. Oct. 1, 1927.

Chemical process for the removal of superfluous solder from metallic objects. H. Ditz and R. May, Prague, Czechoslovakia. No. 262,627. May 23, 1927, in Czechoslovakia May 27, 1926

Process for the utilization of sheet iron scrap. A. Dossmann, Genoa, Italy. No. 262,759. Sept. 22, 1927.

Process for providing all kinds of surfaces with a coating which is resistant to chemical action. M. Lehnig, Dresden, Germany. No. 262,643. Sept. 16, 1927.

Method of relieving the stresses from the autogenously or electrically welded joints in pipes. Mannesmannröhren-Werke, Düsseldorf, Germany. No. 262,820. Oct. 1, 1927.

Improvements to arc welding machines. O.M.E.S. Officine Macchine Elettro-Siderugiche, Novarra, Italy. No. 262,505. Sept. 13, 1925.

Process for forming metallic coatings on plane surfaces. L. Rado, Berlin-Halensee, Germany. No. 262,889. Sept. 21, 1927.

Apparatus for bending lead tubes of any diameter to any radius. M. Trenta, Rome, Italy. No. 262,708. July 10, 1928.

Device for casting metals. J. Züblin, Singen a.H., Baden, Germany. No. 262,859. Oct. 11, 1927.

Connections for high-frequency heating apparatus, especially melting furnaces. Siemens & Halske, Berlin-Siemensstadt, Germany. No. 262,596. Sept. 17, 1927, in Germany Sept. 21, 1926.

High-frequency induction furnace. Siemens & Halske, Berlin-Siemensstadt, Germany. No. 262,822. Oct. 1, 1927, in Germany June 10, 1927.

Swedish Patents

Subject of Invention, Patentee, Patent No., and Filing Date.

Process for driving off arsenic in the form of arsenic sulphide from ores containing arsenic and sulphur. Metallbank und Metallurgische Gesellschaft Akt.-Ges., Frankfurt a.M., Germany, and A. G. P. Palén, Stockholm, Sweden. No. 68,610. Sept. 20, 1927, abroad Dec. 21, 1926.

Process for the separation of the metalliferous constituents of an ore from each other. Minerals Separation Ltd., London, Englnd. No. 68,626. Mar. 29, 1926.

Process for producing a magnetic material. Electrical Research Products, Inc., New York, N. Y. No. 68,629. Oct. 17, 1921.

Method of making sheet metal radiators by electric line welding. Aktiebolaget Plåtförädling, Hälsingborg, Sweden. No. 68,632. Oct. 19, 1925.

Process and apparatus for sintering slimes and ores in portable sintering pots. Allmänna Ingeniörsbyran H. G. Torulf, Stockholm, Sweden. No. 68,636. Aug. 22, 1923.

Process for the production of aluminum. Aluminium Ltd., Toronto, Ont. No. 68,637. Dec. 20, 1923, abroad Dec. 21, 1922.

Closure device for tunnel furnaces. Eesti Potendi Aktsialselts, Reval, Esthonia. No. 68,642. Dec. 31, 1928, abroad Jan. 17, 1928.

Process and apparatus for cleaning metal objects. E. Harbeck, Partille, Sweden. No. 68,657. Oct. 29, 1927.

Penton Gold Medal Awarded to H. A. Schwartz

Harry A. Schwartz, manager of research, National Malleable & Steel Castings Co., Cleveland, has been selected to receive the 1930 major award of the American Foundrymen's Association, the John A. Penton Gold Medal. This award, which is made to Mr. Schwartz for his outstanding contributions to the foundry industry, has been approved by the Board of Awards and will be presented to him at the 1930 convention, the week of May 12.

Mr. Schwartz is especially noted for his many contributions to the field of research on malleable iron. He has been closely identified with the A. F. A. for many years as a contributor of papers, as a member and chairman of various committees and as chairman of convention sessions. One of his papers was the 1928 A. F. A. exchange paper to the Association Technique de Fonderie de France.

At present he is chairman of two important committees of the malleable division; namely, those on specifications and on recommended foundry practices. He also represents the A. F. A. on Committee A-7 of the A. S. T. M. on malleable iron, and on the ferrous metals committee advisory to the U. S. Bureau of Standards.

Mr. Schwartz' first paper before an A. F. A. meeting was presented in 1918 on the subject of "Malleable Iron as a Material for Engineering Construction." Practically every A. F. A. convention since that time has had some contribution from him in the form of a paper or written discussion.

In addition to his membership in the A. F. A., Mr. Schwartz is a member of the American Society of Mechanical Engineers, American Society for Testing Materials, Society of Automotive Engineers, American Institute of Mining and Metallurgical Engineers—serving as vice-chairman of the Northern Ohio Chapter in 1924–1925—the American Society for Steel Treating, the Iron and Steel Institute (British), the American Chemical Society—serving as the first secretary of the Indianapolis chapter—the Research committee of the Malleable Iron Research Institute and the Cleveland Engineering Society.

Mr. Schwartz is the author of the outstanding book on malleable iron, the first edition of "American Malleable Cast Iron" being published in 1922. In addition to his contributions to A. F. A. sessions, he has presented numerous papers before meetings of the A. S. S. T., A. I. M. E., S. A. E., American Ceramic Society, American Welding Society, World Engineering Congress held at Tokio, Japan, in 1929 and to the technical press.

At present he is adviser on malleable iron for the foundry and is serving also as a special lecturer on the metallurgy of cast iron at the Case School of Applied Science, Cleveland. In recent years the company with which he is connected has been producing steel castings, and he has been doing research work on alloy steels, especially in connection with wear and oxidation-resisting products.

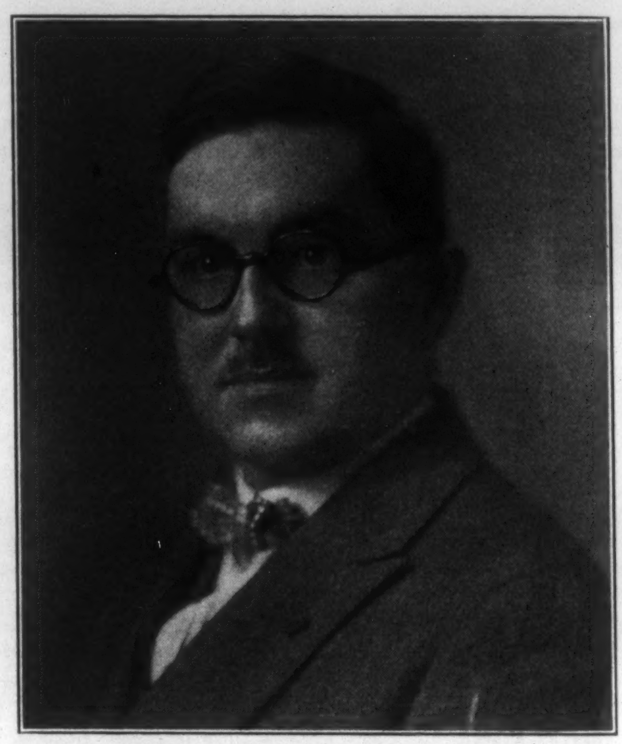

Photo Frank Moore Studio, Cleveland. Courtesy—Iron Age

His formal technical training was obtained at Rose Polytechnic Institute, Terre Haute, Ind., where he received three degrees—Bachelor of Science in 1901, Master of Science in 1903 and Mechanical Engineer in 1905. He also served as instructor at this institution in 1901–1902, and has retained an active interest in the school. He served for one year as chairman of the Rose Alumni Association, and for five years has been chairman of the Cleveland Chapter and a member of the executive committee of the national alumni association.

New Westinghouse Research Laboratory. An expenditure of $1,500,000 will be made by the Westinghouse Electric and Manufacturing Company in the construction of a central engineering laboratory and an addition to the present direct current power laboratory, both in East Pittsburgh. The new laboratory will eventually replace numerous smaller laboratories and experimental test sections now scattered throughout the plant.

William C. Eakin has been appointed Eastern District Sales Manager of the Detroit Alloy Steel Company with offices at 707 Berkshire Avenue, Pittsburgh, Pa. This company Manufactures PRK-33 patented Cobaltcrom Air Hardening Tool Steel Castings under sole manufacturing rights secured from Darwin & Milner, Inc., Cleveland, Ohio, American Division of Darwin's, Ltd., Sheffield, England.

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Reviews of Manufacturers' Literature

In this department we shall list each month a selection of the catalogs, books, treatises and other printed matter issued by manufacturers which, in our judgment, should be of interest to the readers of METALS & ALLOYS. *Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter for consideration by the editor of this department are invited to do so, and it is suggested that* METALS & ALLOYS *be placed on the regular mailing list so that advance copies of any material of interest to the metallurgical field may automatically come to this department.*—EDITOR.

The Story of Boronics.—Booklet on the subject of Boronics for alloying, deoxidizing and solid-casting all metals. This booklet is intended as a Foundryman's Pocket reference on Boronics and also contains various pages of data which it is hoped will be helpful in daily tasks. American Boron Products Co., Inc., Buffalo, N. Y

Powdered Fuel in Metallurgical Work.—Interesting paper delivered at the world Power Conference. Contains historical data, cost of preparation, copper furnaces, application to various iron and steel furnaces, galvanizing and tining, sintering, miscellaneous uses, etc. Combustion Engineering Corp., 200 Madison Ave., New York, N. Y.

Green Chain Grate Stoker (Natural Draft).—New catalog describing and illustrating this product. Shows three typical evaporative tests and drawings with applications of stoker to various types of boilers. Combustion Engineering Corp., 200 Broadway, New York, N. Y.

Corhart Electro-Cast Tank Blocks.—Leaflet illustrating and describing this new Flux Block. Corhart Refractories Co., Inc., Louisville, Ky.

Cambridge Wire Cloth.—Booklet illustrating and describing wire cloth, wire screens, wire belts in iron, steel, brass, copper bronze, aluminum, nickel, monel metal, nickel-chrome, gold, silver and platinum. Cambridge Wire Cloth Co., Cambridge, Maryland.

Furniture Catalog.—New catalog No. 16 of laboratory, home economics, vocational and library furniture. Fully illustrated. Price lists. Measurements. Specifications. Chemistry and physics floor plans, etc. Leonard Peterson & Co., Inc., 1222 Fullerton Ave., Chicago, Ill.

"Bridgeport Plumbing Supplies."—Handsome looseleaf catalog in substantial binder containing full information on tubular plumbing supplies. This is a complete catalog. Also contains handy chart for figuring brass pipe weight. Bridgeport Brass Co., Bridgeport, Conn.

Connersville Bulletin No. 305.—Illustrates by views of different installations, the adaptability of Connersville Rotary Patented Displacement Meters to the usual as well as ordinary requirements, for the dependable accurate measurements of gas in manufacturing, distribution and industrial consumer installations. The Connersville Blower Co., Inc., Connersville, Indiana.

Electroplating Equipment. Motor generator sets, specially designed for electroplating and other electrochemical processes are illustrated and described in a recent 16-page bulletin. Voltage regulators, control panels and other accessories are included. Columbia Electric Mfg. Co., 1292 East Fifty-third St., Cleveland, Ohio.

Excess Pressure Regulation.—Bulletin S-19 illustrates and describes the "S-C" Type S L differential pressure valve, Valve governing motor driven centrifugal feed pump. Specifications. Cross sections, charts, typical installations, etc. The Swartwout Company, 18511 Euclid Ave., Cleveland, Ohio.

Horse Head Zinc in Die Castings.—Attractive booklet illustrating and describing die castings for numerous uses. The New Jersey Zinc Co., 160 Front St., New York, N. Y

Oxwelded Piping.—Booklet containing helpful and instructive information on the installation of Oxy-Acetylene Welded Piping for industrial uses and also for the heating of domestic and industrial buildings. The Linde Air Products Company, 30 East 42nd St., New York, N. Y.

Published by the same firm, "Airplane Fuselage Welding," booklet of interest to all persons engaged in the manufacture of aircraft.

The Ideal Electrical Principle Applied to Zinc Melting.—Booklet describing new type of electric furnaces for melting zinc and zinc base alloys. The Ajax Metal Co. (Electric Furnace Dept.), Frankford Avenue, below Girard Ave., Philadelphia, Pa.

Potentiometer Recording Pyrometer.—Booklet illustrating and describing this instrument, New Model No. 8201. Wilson-Maeulen Co., Inc., 383 Concord Ave., New York, N. Y.

Case Loose-Leaf Catalog.—Illustrates and describes supplies and accessories for heat-treating plants. Contains useful information on treatment of various steels after carburizing. Tables of melting temperatures, weights, etc. Price lists. The Case Hardening Service Co., 2281 Scranton Road, Cleveland, Ohio.

Precision Measurements in X-Ray.—A discussion for Roentgenologists by Montford Morrison. Deals with subjects of intense interest. American X-Ray Corp., 711 West Lake St., Chicago, Ill.

Published by the same firm, "Coronaless X-Ray Apparatus," by Montford Morrison.

Leitz Catalog No. 1089.—This publication includes Leitz Metallographic Microscope, accessories and photo-micrographic equipment of less elaborate construction than the Leitz micro-metallograph for which the Leitz instrument is universally recognized. This bulletin is offered to those laboratories who are favorably inclined toward consideration of a less elaborate microscopical construction with the result in saving of expense. E. Leitz, Inc., 60 East 10th St., New York, N. Y.

Inland Rail Steel Products.—Handy booklet, stiff cover, illustrating and describing rounds, squares, flats, angles, U-bars, I-bars, tees, agricultural implement shapes, channels, channeled flats, special sections and shapes, concrete reinforcing bars, red top fence posts. Tables of weights and thicknesses, etc. Inland Steel Company, First National Bank Bldg., Chicago, Ill.

Published by the same firm, "Making Steel Briefly and Simply Told."

Scott Testers.—Booklet illustrating and describing abrasion testing machines for rubber. Henry L. Scott Co., Providence, R. I.

Perforated Metals.—Catalog illustrating and describing elevator buckets, light and heavy steel plate construction. Tables of sizes and perforations. Fully indexed. Hendrick Manufacturing Co., Carbondale, Pa.

Equipping Modern Chemical Plants.—Book containing summary of advertisement of manufacturing featuring Monel Metal and pure Nickel construction of their equipment. Because of wide variety of equipment covered in these pages the book is valuable for references purposes. The International Nickel Co., 67 Wall Street, New York, N. Y.

Bronze Products.—Reference book of bronze products for engineering purposes. Contains information of Hy-Ten-Sl, a bronze as strong as nickel steel. Pertinent facts regarding the development, physical characteristics and uses of Hy-Ten-Sl, "the strongest bronze." American Manganese Bronze Co., Holmesburg, Philadelphia, Pa.

"Mico" Alloys.—Booklet illustrating and describing non-corrosive, high temperature, hot working, heavy duty composite castings. Millbury Steel Foundry Co., Millbury, Mass.

Dorrco.—Bulletin No. 7071. The work and scope of the Dorr Company. Illustrates and describes equipment for chemical plants such as washers, classifiers, sizers, etc. Very interesting data. The Dorr Co., 247 Park Avenue, New York, N. Y.

Ovens.—Booklet No. 29- L illustrates and describes ovens for metal lithographing and coating. Installation charts, details. Young Brothers Company, Detroit, Michigan.

Published by the same firm, "Ovens for the Electrical Industry" No. 27-E.

Willson Products.—Booklet illustrating and describing Willson personal productive products for industry. Catalog No. 29. Willson Products Inc., Reading, Pa.

That These Walls May Stand.—Attractive little booklet containing facts that everyone should know about pipe. Reading Iron Company, Reading, Pa.

Published by the same firm, "Pipe Pointers for Home Builders."

Ampco Non-Sparking Tools.—Catalog illustrating and describing line of Ampco Non-Sparking Tools. Price list, etc. American Metal Products Co., 34th Ave. and Burnham St., Milwaukee, Wisconsin.

An Investigation of the Failure of Flame-Cut Wind-Bracing Brackets.—This Bulletin of 136 pages contains an exhaustive study of the subject indicated. The chapter heads are as follows: Introduction; Study of Broken Wind-Bracing Brackets; Physical Properties of Metal in Broken Brackets; Metallographic Examination of Broken Brackets; Study of Effects of Formative Processes; Detection and Measurement of Strain; Strains in Rolled Sections; Strains Produced by Punching; Strains Due to Local Heating; Study of the Effects of Plastic Strain and Heat upon the Physical Properties; Izod Impact Tests; Hardness Tests; Static-Bend Tests; Tension Tests; Drop Tests on Brackets; Static-Bend Tests on Brackets; Summary; Conclusions; Recommendations; Acknowledgments; Bibliography. There are 45 plates and eight diagrams. A copy of the Bulletin may be secured from the Civil Engineering Testing Laboratories of Columbia University, New York City.

Steel Treating Instrument Data Book. This 32-page (8″ x 10$^1/_2$″) well-illustrated booklet presents a summary of 23 different heat treatment processes where temperature control is important, covering annealing, hydrogen copper brazing, carburizing, etc. Each process is briefly described and the heat treatment best suited to the need is outlined, and the types of furnaces and instruments ordinarily used are indicated. The necessity for close temperature control for best heat treating results necessitates the use of accurate instruments, and a short paragraph on each process listed in the "Steel Treating Instrument Data Book" indicates the Brown instrument or control best adapted to the conditions. This new booklet conveys to its readers an interesting picture of the important part played by indicating and automatic control pyrometer equipment in modern heat treating operations and is well worth reading. The Brown Instrument Company, Philadelphia, Pa.